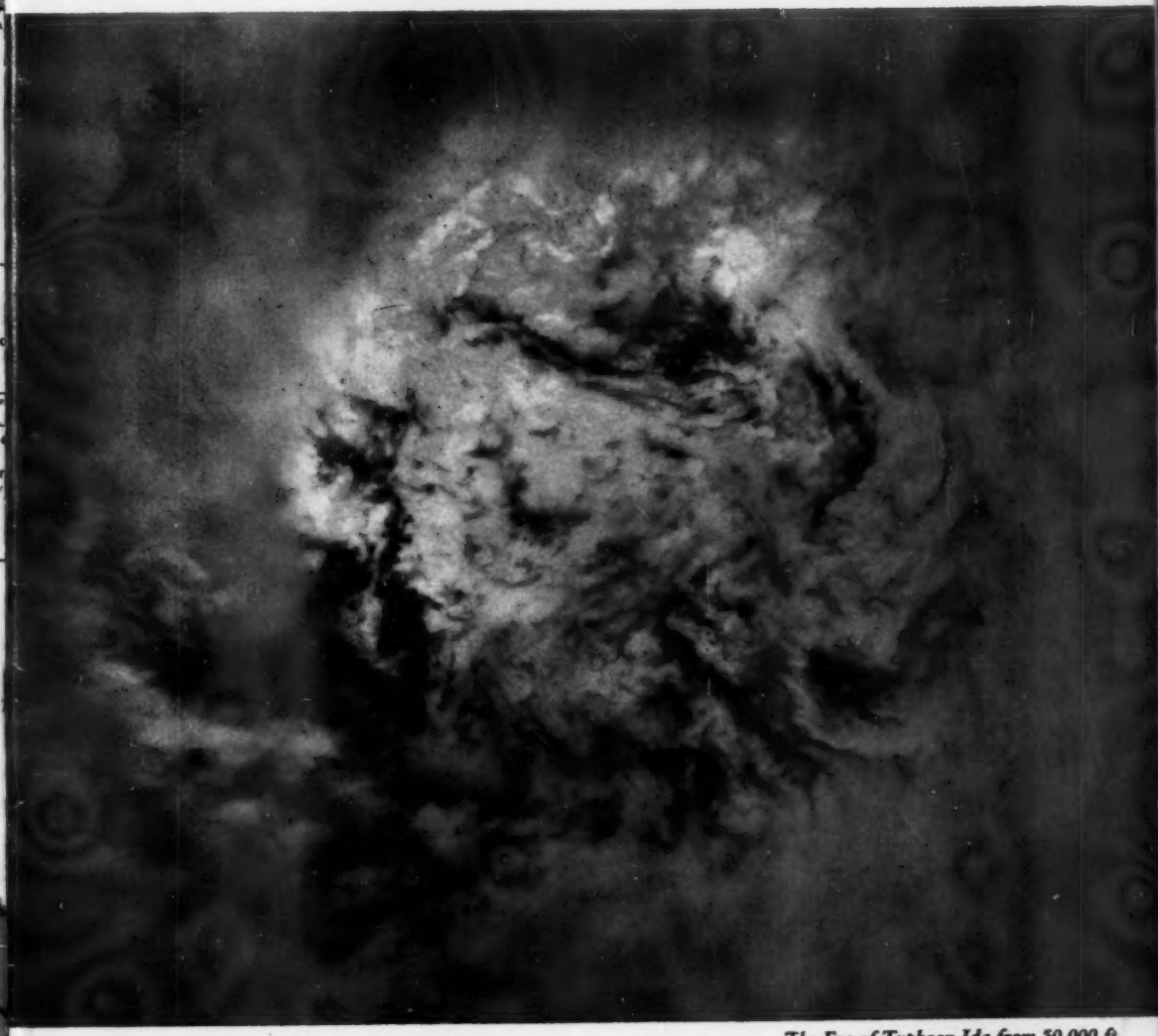
Weatherwise



The Eye of Typhoon Ida from 50,000 ft.

Volume 12, Number 2 **April 1959**

"SOME PEOPLE ARE WEATHERWISE BUT MOST ARE OTHERWISE"—BENJAMIN FRANKLIN

WEATHERWISE

THE MAGAZINE ABOUT WEATHER

DAVID M. LUDLUM, *Editor* HENRY W. BULKLEY, *Associate Editor*

Summer School for High School Students

THE American Meteorological Society has been awarded a grant by the National Science Foundation for support of a Summer Science Training Program for Secondary School Students under the direction of Dr. Vincent J. Schaefer. The Atmospheric Sciences Program will be carried on at the Loomis School in Windsor, Connecticut, 21 June through 9 August 1959.

The objectives of the program are to give opportunity to promising secondary school students to gain an increased understanding of scientific content and methods through instruction given by persons of recognized scientific stature and to help develop cooperation between colleges and high schools in increasing the quality of education in the sciences.

Thirty male students from throughout the country will be selected on the basis of school records, special tests and interviews. All applicants must have completed the 11th grade by June 1959. Candidates who wish to make application should rank very high in their class, should have completed three years of mathematics and one year of chemistry or physics in secondary school, and should have a keen curiosity in the area of science. Current 12th grade students are not eligible.

(*Continued on page 86*)

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Front Cover: The eye of Typhoon Ida as viewed from a U-2 jet aircraft from about 50,000 ft. altitude. Photo was taken at about 1100 local time on 24 September 1958. Sunshine coming from the south-southeast, lower right, can be seen on the wall cloud in the northern and western quadrants. Broken clouds in eye are low stratus. See article on page 62. U. S. Air Force photo.

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St. Louis Tornado 10 February 1959

G. N. BRANCATO,
Meteorologist-in-Charge,
U. S. Weather Bureau,
St. Louis, Missouri

DURING the early morning hours of 10 February 1959, a tornado dipped down in the outskirts of St. Louis near the little town of Sherman, Missouri, along the Meramec river. Here the tornado did its first damage by lifting the roofs of a few houses and doing some damage to other property. A short time later, the tornado touched down again in the Warson Woods development of St. Louis county. From this location it hopskipped along a path to near the center of the city where the maximum tornado damage occurred. After hitting the center of the city, the tornado apparently lifted as it approached the river and did very little damage east of the Mississippi. The path of the storm is shown in detail on the attached map.

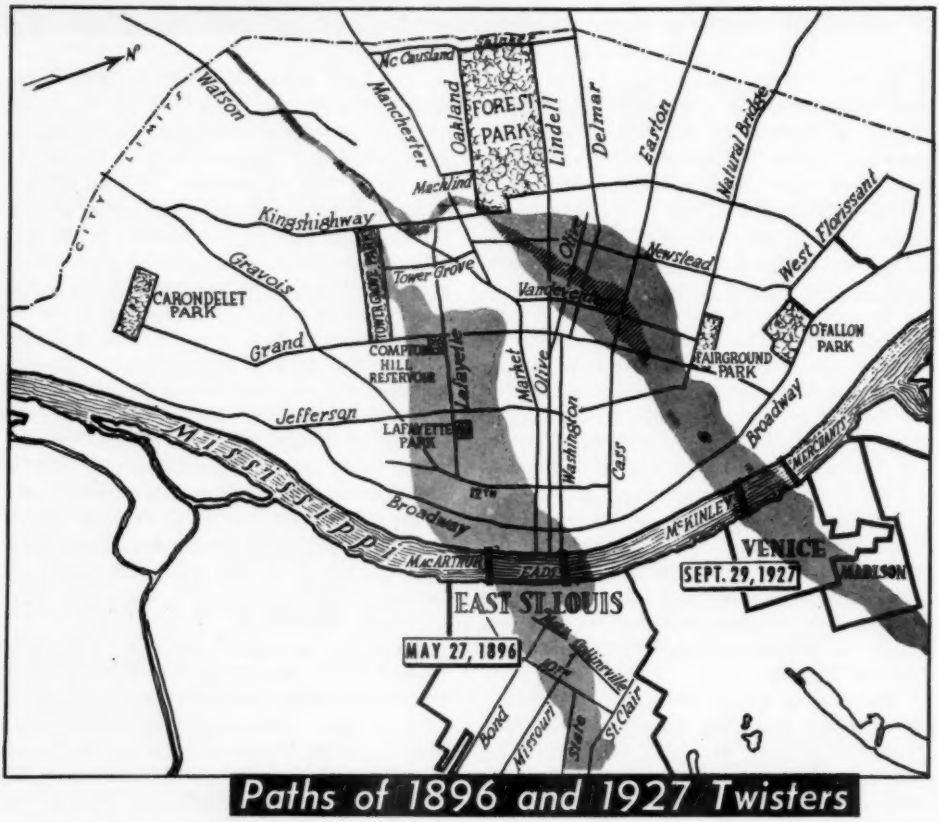
The tornado struck the outskirts of St. Louis shortly after 0200 and hit the center of the city between 0213 and 0220. It was the worst storm to strike St. Louis in a generation, and the path of the storm was very similar to the path of the 1927 tornado which claimed 70 lives.

The tornado was preceded during the night by a series of intense thunderstorms which produced between one and three inches of rain over the area and caused flash floods in many of the streams in the greater St. Louis area. By 2300 the heavy rains and most of the intense thunderstorm activity had moved to the east of St. Louis, and there were breaks in the clouds with stars clearly visible for a period of time. At about 0100 the St. Louis radar began to pick up a squall line approaching at a speed of approximately 30 knots. As the squall line approached, it was evident from the echoes that there was rather intense thunderstorm activity. Between 0100 and 0200 a few reports were received from Severe Weather Observers in the path of the squall line reporting winds estimated at 40 to 50 knots and some hail. A severe thunderstorm warning had been in effect since the preceding evening and extended until 0230 for the St. Louis area. The thunderstorms were occurring in advance of a Pacific cold front in warm, moist, and very unstable air. The St. Louis area was near the apex of a frontal wave formed by an east-west warm front which extended between St. Louis and Springfield, Illinois, and the Pacific cold front which extended southwestward from the warm front just west of St. Louis.

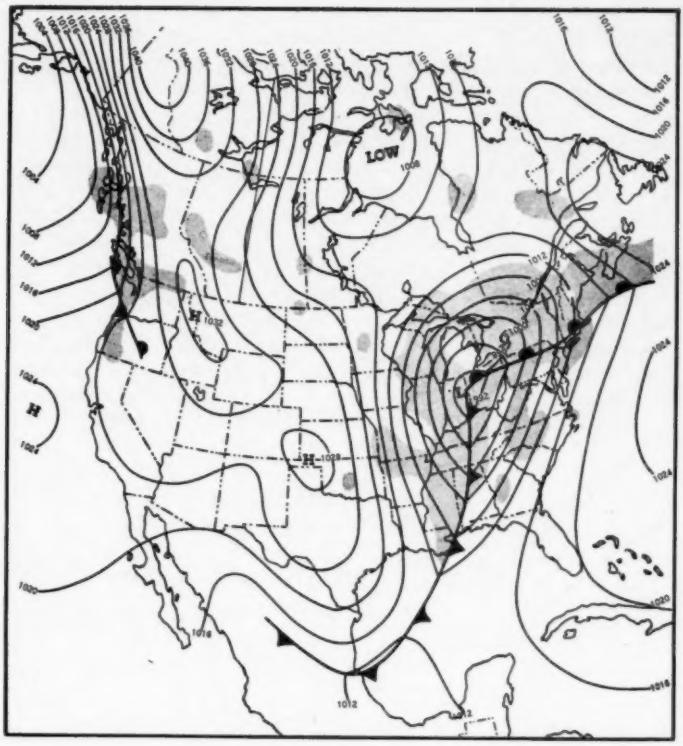
Although the squall line was apparently moving at the rate of approximately 35 mph, the tornado moved across the city at a rate of 60 to 65 mph. In its travel across the county and city, it dipped down in the Warson Woods area for a distance of several blocks unroofing houses and causing considerable damage. A little further along when approaching Forest Park, it toppled the 575 foot steel tower of television station KTVI and damaged many

houses and buildings. It then dipped down into Forest Park uprooting many trees in its path. On the other side of the park the whirl slammed into several hotels breaking hundreds of windows on the park side of the buildings. From here the tornado lifted shortly, but then it came down with its full fury in the vicinity of Oakland and Oakview and Olive and Boyle Streets. In this area the storm did its major damage and caused most of the deaths. When the work of sifting through the ruins was completed, the following damage and casualties were reported:

Persons killed	21
Persons with major injuries or illnesses	72
Persons with minor injuries	273
Persons hospitalized	72
Dwellings destroyed	16
Dwellings with major damage	102
Dwellings with minor damage	750
Dwellings approximate number insured	46%
Dwellings approximate number owner-occupied	15%
Other buildings destroyed	31
Other buildings with major damage	142
Other buildings with minor damage	858
Total families suffering loss	3,036
Total property damage approximately	$10,000,000



Paths of the 1896 and the 1927 tornadoes are shown on above map. Areas of heaviest 1927 damage have diagonal lines. The 1959 twister crossed the southeastern corner of Forest Park and then followed the 1927 track closely, causing major damage in the Oliver Street area. Courtesy of the St. Louis Post-Dispatch.



The surface map for 1300, 21 January 1958, showing the storm center on the Indiana-Ohio line. USWB chart.

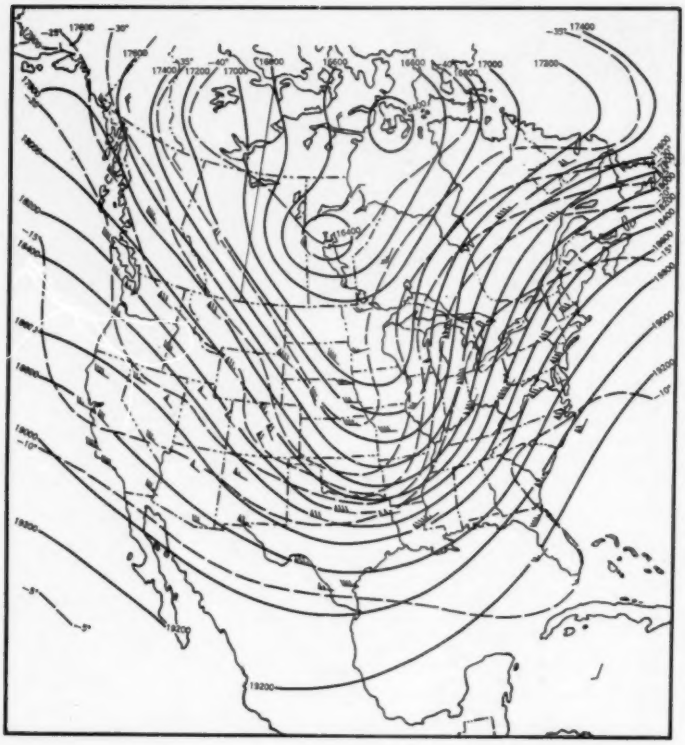
The Great Midwinter Storm of 20–22 January 1959

R. A. TREIDL, *Meteorological Service of Canada*

SEVERE winter storms are a fact of life on the North American winter scene, but once in a while a storm shapes up that lingers for many years in the memories of the stricken. The following is the tale of such a ferocious winter storm that caused untold suffering, and left a trail of destruction across the continent.

January's weather was dominated by a huge depression over Hudson Bay, which caused the high level planetary winds to sweep from Alaska southeastward into the Gulf of Mexico, i.e. far south of their normal latitude, before turning northeastward along the Atlantic seaboard. For many weeks, intense cold held the heart of the continent in an icy grip, piling up masses of snow in the lee of the Great Lakes. Record depths of snow were observed especially along the southern and eastern shores of Lake Ontario.

On Monday, 19 January, a weak weather disturbance, one of a series, moved eastward across the Great Lakes region, causing a few inches of fresh snow. This was followed by a minor outbreak of cold air from the northwest. The cold wave subsequently split in a peculiar manner; the main thrust of the cold wave drove southward into Texas, while a weak push spread a thin layer of Arctic air across the upper Mississippi Valley, the Ohio Valley, and the New England States. The leading edge of this outbreak came to a halt



The contour map of the 500-mb surface (20,000 ft. c.) at about 1900, 21 January 1959. USWB chart.

along a line extending from Long Island into the Ohio Valley, across the Mississippi, to the Texas Panhandle, and into New Mexico where Tuesday morning the air pressure had dropped below normal. Here the storm was born. Southerly winds to the south of this line kept the Gulf States supplied with mild and moist air. Early morning readings in the fifties and sixties were followed by afternoon temperatures in the seventies. Thunderstorms hinted of worse things to come.

The forces in the sharply contrasting air masses were great, yet balanced. In Kansas and Nebraska, where the cold air was firmly entrenched, continuing snowfalls piled up 12 inches in 24 hours. East of the Mississippi, however, the cold air had dwindled to a depth of a few hundred feet above the chilled ground. The warm winds blowing over this layer of chilly air brought freezing rain to parts of Illinois, Indiana, and Ohio, resulting in glaze nearly one inch thick. Heavy tree damage resulted in broken limbs which severed power and communication lines. All air travel was grounded and traffic slowed to a snail's pace. For sections of the abovementioned states, this was the worst glaze in 25 years, while others had not seen anything like it in 40 years.

By late Tuesday, the embryo storm had moved into Missouri, pushing the warm air masses northward to the shores of Lake Erie, while frigid Arctic air began to flow southeastward from the Midwestern states. A sudden thaw occurred in the Ohio Valley, when temperatures rose into the sixties overnight. Heavy showers and thundershowers deposited three to five inches of rain, which the still-frozen ground was unable to absorb. Ice-clogged rivers burst free and hurled huge chunks of ice downstream causing ice jams and numerous flash floods.

By noon Wednesday the 21st, the embryo had grown into a full-fledged storm with a deep centre in Indiana. A vast belt of freezing rain extended from Maine across southern Quebec and Ontario into Michigan. Cold air rushing into the wake of the storm blew

up blizzard conditions from Wisconsin southward into the lower Mississippi Valley, dumping 10 to 20 inches of snow near Lake Michigan. The temperature drop along its leading edge amounted to 30 to 40 degrees within a few hours. Tearing into the moisture-laden southerly winds and wedging the warm air upward, the upheaval precipitated torrential showers and thunderstorms along its way through the Southeastern states, climaxed by tornadoes in sections of Tennessee and Kentucky.

Upon reaching the lower Great Lakes, the storm centre began to accelerate, moving at 40 to 50 mph through southern Ontario into central and northern Quebec with a central pressure down to 968 mb. The mild air swept over the New England states into the Canadian Maritime provinces, breaking temperature records and depositing two to three inches of rain in Nova Scotia, while temperatures plunged to sub-freezing levels as cold air masses swept across the lower Great Lakes into the eastern United States, almost freezing the floods in their tracks.

Thursday evening the 22nd saw the storm centre leave the continent in the Ungava region. The cold wave in its wake continued to spread over the eastern parts of the continent; and when the winds died down, temperatures had dropped to sub-zero levels as far south as New Mexico and Oklahoma.

The Midwinter Storm in Illinois

LOTHAR A. JOOS, *State Climatologist, U. S. Weather Bureau, Champaign, Illinois*

THE most severe storm of the midwinter season moved through the central part of the country during the period 20–21 January 1959. A single massive storm system produced cold waves, blizzards, sleet and heavy glazing, windstorms, tornadoes, and flood-producing rains. Greatly contrasting conditions were observed over relatively small areas as evidenced by reports from Illinois.

METEOROLOGICAL

As the principal low center formed over Arkansas on 20 January and moved northeastward across southern Illinois, areas near the Ohio River had heavy rains, thunder, southerly winds, and temperatures above 60°. At the same time some of the northwestern counties were experiencing readings near 20°, heavy snow, and northeasterly winds. As the tropical air mass was lifted along the front, the familiar "sandwich" of warm air and liquid precipitation between upper and lower layers at sub-freezing temperatures produced sleet and freezing rain in a 500-mile long ribbon extending from Springfield, Missouri, to Detroit, Michigan. Near the middle of the ribbon lay central Illinois where icing conditions were at their worst. Fortunately, the precipitation there ended during the afternoon of 21 January.

WEATHER EFFECTS

Northern parts of Illinois received 8 to 12 inches of snow with strong drifting winds which closed highways about as fast as the snowplows could reopen them. Most schools and factories in the north were shut down for at least a day because of hazardous driving conditions. At Bloomington the storm comprised the worst sleet and ice storm since 1948, at Freeport the heaviest snowfall since 1947, and at Mt. Carroll the worst snowstorm since at least 1920.

While heavy snow was troubling northern regions, extreme southeastern Illinois caught two to four inches of rain on still frozen topsoil. Storm runoff became rapid, small streams rose quickly, and some flash flooding resulted.

Storm conditions were most severe in the central third of the State where heavy glazing continued for ten to twenty hours. Snow, sleet, and ice covered the ground to a depth of two to five inches. Clear ice of one-half

to one inch in thickness covered all exposed objects. The weight of the ice broke tree branches of all sizes and downed a number of overhead wires, but the bulk of the extensive damage to power and communications lines was caused by broken tree limbs falling across the cables.

The zone of heaviest icing included the cities of Springfield, Decatur, Champaign-Urbana, and Danville, communities with a total urban population of 250,000 persons. Thousands of homes in the area were without electric power, much discomfort resulted as outside temperatures dropped to near zero, and unheated residences were threatened with freezing pipes. Many families moved in with more fortunate friends who had power, and some sought shelter in hotels. Public buildings were opened for emergency sleeping though very little use was made of these facilities. Most hospitals had emergency power available. In the rural sections farmers had to haul water for stock, and dairymen were unable to operate milking machines.

Past Glaze Storms

In the Springfield area this was the heaviest ice storm since 17–18 December 1924 when 0.3 to 0.8 of an inch of ice accumulated over a broad band extending from Bloomington southwestward to near St. Louis. Damage to public utilities during that storm was considerably more severe, possibly because electric and telephone lines of that period were of lighter and more open construction. An even heavier ice storm struck the Springfield area on 2–4 February 1883. Weather records in the Champaign area are less complete, but apparently there has been no ice storm of comparable severity in the 50 years prior to 1959.

A street scene at Springfield, Illinois, after the severe glaze storm of 20–21 January 1959. Photo by Illinois State Journal & Register.

Record Snowfall in Sunny Southern Arizona

RODERICK S. QUIROZ, *Climatic Center, Hq., Air Weather Service*

DURING the second half of 1958, the normally quiet weather of southern Arizona was disrupted by two singular, record-breaking events—a 4-inch rainfall on 29 July, and a 6-inch snowfall on 16 November, both occurring at Tucson. The latter was not only the greatest snowfall ever recorded at Tucson since the local record began in 1892, but was also the first snow ever to be observed in the month of November. This unusual snowfall startled the local residents, but it also must have taken some meteorologists by surprise, if one considers that, climatologically at least, snow in November was just not "in the books," much less in the amount recorded.

Snow fell over much of Arizona that day. According to newspaper accounts and Weather Bureau crop reports, the resulting damage was not exceptionally great. Several state and national highways were temporarily closed and others considered hazardous. In Tucson itself, many tree limbs broke under the weight of the snow. In parts of Arizona, the harvesting of cotton was somewhat retarded, and low temperatures on the morning of the 17th caused some damage to citrus groves, although mostly to the leaves of young trees. The more serious aspect of the storm, however, was the loss of human lives. On the afternoon of the 15th (the temperature had risen to 67° F), a group of six thinly-clad boy scouts started to climb Mt. Baldy (elevation 9,400 ft.), near Tucson; three of the boys turned back halfway, but the other three were never heard from again, despite a week-long search involving as many as 700 men. Some 13 other persons were lost, but were ultimately accounted for. Fifty others were temporarily marooned at Mt. Lemmon Lodge, snowbound by accumulations up to 30 inches near the peak.

Tucson is a mecca for winter visitors. It lies in the zone of maximum sunshine for the United States: its annual percentage of possible sunshine averages 86%, with 5 months of the year having more than 90% and none less than 70%. On an average, approximately 192 days of the year are clear (cloud amount 0 to 3 tenths), 92 are partly cloudy (4 to 7 tenths), and 81 are cloudy (8 to 10 tenths). The cloudy days are predominantly those with high thin cirrus, so that solar radiation reaching the ground is, nevertheless, substantial. Daily maximum temperatures in winter are mainly in the sixties and seventies; heavy clothing is rarely needed, even at night.

Precipitation is slight, about 11 inches per year. Half of this falls in air mass thunderstorms in July, August, and September; a secondary maximum, in winter, is attributable to Pacific frontal systems which manage to penetrate into Arizona and New Mexico. Snow is rare in Tucson. The years 1931–1958 are almost evenly divided among years with no snow at all, those with only a trace, and those with snowfall greater than a trace. Table 1 gives the monthly distribution of all occurrences of snowfall during this period. A glance at the table will show how strikingly anomalous the 6.4-inch snowfall of 16 November was from a climatological standpoint.

TABLE 1

FREQUENCY DISTRIBUTION OF 24-HOUR SNOWFALL AMOUNTS, IN INCHES, AT TUCSON, ARIZ., 1931–1958

Amount	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.
Trace		5	6	9	5	
0.1–1.0			2	2		1
1.1–2.5		2	1	1		
2.6–5.0			1*			
>5.0	1*					

* Record maximum on 16 Nov. 1958, 6.4 in.; previous official maximum, 3.5 in., was recorded on 25 Jan. 1949.

Synoptically, while the surface pressure pattern associated with widespread snow in southern Arizona is highly variable, the upper-air pattern, particularly at 500-mb, is more consistent and perhaps more useful as a predictor. An inspection of all situations which resulted in more than a trace of snowfall at Tucson during the 10-year period 1949–1958 showed certain features in common at the 500-mb level. In all but one case,

a closed low center with a central height value of 17,800 ft. or less, and temperatures around − 30° C or lower, entered the northwest sector of a circular area with radius approximately 500 miles, centered on Tucson; the associated snowfall at Tucson began some time within the next 48 hours. The single non-conforming case was a situation in which a deep trough, rather than a closed low, entered the area, although the requisite values of pressure height and temperature were nevertheless satisfied.

The small frequency of intrusions of this nature makes the phenomenon useful for predicting snow at Tucson. A critical value of − 30° C seems reasonable; since the air at 500-mb should not be any warmer to insure that, from adiabatic considerations, the freezing level should be found fairly close to the ground. Air near the ground with above-freezing temperatures at the outset of snow may cool sufficiently by factors other than advection to allow snow to persist in solid form down to station level (1).

Thus far we have spoken of a situation at 500-mb which was common to all cases of appreciable snowfall at Tucson. The question may then be asked: is this situation peculiar only to snowfall occurrences, or could this situation perhaps lead to the occurrence of non-frozen precipitation, or perhaps no precipitation at all? In other words, though it appears that this situation at 500-mb is a prerequisite to appreciable snowfall at Tucson, is it also a *sufficient* antecedent condition?

To find the answer to this question, five sets of winter months of daily 500-mb maps (Dec., Jan., Feb., 1952/53–1956/57) were examined, and all dates on which the requisite situation occurred were noted down. These were then compared with the observed dates of snowfall. As might have been anticipated, the matching dates were in the minority, indicating that the forecaster must take other factors into consideration. The rate of cold air advection into southern Arizona should certainly be evaluated, since while the necessary cooling may take place at the periphery of the area to the northwest of Tucson, not in every case would it follow that sufficient cooling would occur in the immediate vicinity of Tucson. It is noteworthy that in the fifteen winter months examined, there were only 12 potential situations for the occurrence of appreciable snowfall at Tucson. And although snow occurred in only three cases, the small number of potential cases makes the forecasting problem a less burdensome one.

The snowstorm of 16 November was indeed unusual. Lest it cause undue alarm to Easterners who have delighted in describing the wonderful winter climate of southern Arizona to their friends, it should be noted that by the morning following the storm, the sky promptly cleared up, 10½ hours of sunshine were recorded that day, and by the 20th, afternoon temperatures were once more in the seventies.

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1. Penn, Samuel, The prediction of snow vs. rain. U. S. Weather Bureau Forecasting Guide No. 2, 1957.
2. U. S. Weather Bureau, Local climatological data, Tucson, Arizona, 1941–1958. And: Station Climatological Record, 1931–50.

Cattle seek protection from unusual November snow in southern Arizona. Photo by Jack Shaeffer for Arizona Daily Star.

Oswego Snowburst

"IN my 34 years as a government weatherman and in the four years I've been operating a private weather station here, I've gone through a variety of weather disturbances—blizzards, hurricanes and tropical rainstorms—but never anything like this. It's just utterly fantastic." So wrote Elmer Loveridge, longtime official-in-charge of the Weather Bureau at Oswego on the southeastern shore of Lake Ontario in New York State, in a press dispatch at the conclusion of the intense snowburst which made national headlines in early December.

The day of the big snow commenced at 1100 on Sunday morning the 7th and continued until 1600 on Monday afternoon. A total of 40 inches was measured at Oswego State Teachers College by cooperative observer, Charles B. Yager, who supplied the data below.

Snowfall records at Oswego have been maintained since 1885. The December 1958 totals appear to have broken both the greatest monthly and greatest 24-hour amounts by wide margins. On 17 January 1959 an amazing lee-shore snowburst of 51″ in 16 hours struck Bennetts Bridge, a 670′ hill exposure about 30 miles east of Oswego and generally the snowiest weather bureau station in the Eastern United States.

SNOWFALL AND ACCUMULATION AT OSWEGO, NEW YORK
27 NOVEMBER 1958 — 31 MARCH 1959

Day of Month	November		December		January		February		March	
	Fall	Acc.	Fall	Acc.	Fall	Acc.	Fall	Acc.	Fall	Acc.
1			T	9		21	.2	16		18
2			1.5	10		20	.3	16	.3	18
3				8		19		16		17
4				6		18	T	15	.2	17
5				3	1.5	19		15		17
6			1.5	4	T	19		15		14
7			3.6	7		19	10.4	25	.3	14
8			40.0	44	.4	19	1.1	21		14
9			6.0	47	1.2	20		20	1.8	15
10			8.4	46	4.2	23	2.1	20		15
11			6.2	44	4.3	26	1.1	20		15
12				38	T	25	1.6	21	.6	15
13			2.3	39	1.4	25		20	4.2	19
14			4.8	38		24		19		16
15			T	36		22		18		14
16			2.5	36	4.8	26		18		9
17			2.2	35	6.1	31	.6	18	.1	8
18			T	34	3.8	32	.3	18		8
19			1.2	32		31	2.7	19		7
20			T	31	1.2	29	1.3	19		4
21			1.5	30	T	27	1.1	20		T
22			3.2	29		18		19		T
23				27		17		19		T
24			.2	26		17	3.8	22		T
25			.1	25	3.7	20	T	21		T
26			.6	25	.3	20		21		T
27	1.0	.5		24		20	.2	20	2.0	2
28	.3	.5		23	1.3	21		19	2.0	4
29	8.5	9		22		20				3
30	1.5	10	T	21		17				3
31			T	21	T	16				1
Totals	11.3		85.8		34.2		26.8		11.5	

T = Trace.

(No snowfall recorded in April to 10th)

1958—The Warmest Year of Record on the Pacific Coast

JAMES F. O'CONNOR, *Extended Forecast Section,*
U. S. Weather Bureau,
Washington, D. C.

THE year 1958 was a year of record warmth in many places along the Pacific coast with numerous records broken not only for daily temperatures, but for monthly and yearly values as well. In addition, new records were established in many places for the number of consecutive days and months of above normal temperatures.

Table 1 shows the yearly average temperatures and their anomalies [1] in degrees Fahrenheit for 1958 at representative cities close to the Pacific coast. To provide a comparison with a city close to the coast but cut off from the direct influence of the Pacific Ocean by a mountain range, Fresno, California, has been included. From this table it is evident that most coastal areas set new temperature records or near records for the year. San Francisco airport posted an astounding 4.5° above normal on the yearly average, and 2.6° above the previous record set in 1941. The standard deviation of yearly average temperature at San Francisco is 0.9° F. Thus this year's anomaly was 5 standard deviations above the normal, a truly remarkable event, considering the fact that the chance of such a departure would be about one in a million if annual average temperatures were randomly distributed.

TABLE 1

	1958 Avg. Temp.	Departure from normal	Maximum yearly avg. temp. prior to 1958
Tatoosh Is., Wash.	51.5	+2.2	51.6–1941
Portland, Ore.	57.5	+2.9	57.3–1934
San Francisco, Calif. (airport)	60.1	+4.5	57.5–1941
Los Angeles, Calif.	67.1	+3.2	66.5–1931
San Diego, Calif.	65.5	+3.1	64.4–1931
Fresno, Calif.	63.7	+0.7	65.4–1931, 34, 36

[1] The term "anomaly," used frequently in this article, refers to the departure from normal of a particular value. The normal is taken as a long term average, usually 30 years. The use of anomalies helps eliminate seasonal and geographic differences when comparing values for different periods of time, different geographical influences such as latitude, etc.

Not only air temperatures but also ocean surface temperatures have been noted to be warmer than normal off the North American West Coast, especially in the past two years. The Coast and Geodetic Survey has also reported variations in the monthly sea level (average tidal height) anomalies at various coastal points which appear to parallel the sea surface temperature variations, with a spectacular rise in sea level along the Pacific Coast in January and February 1958. This was attributed to the termination of the more normal upwelling of colder sub-surface water by the abnormal atmospheric circulation in the Pacific during this time as shown in figure 1.

An important manifestation of the abnormal warmth of eastern North Pacific waters in recent years has been the presence of warm water fish at latitudes seldom before observed. A recent press dispatch reported a white sea bass, rarely seen north of San Diego, California, caught in Alaskan waters, barracuda observed off the Washington coast, and the reappearance of sardines near Monterey, California, after several years absence. In addition to the obvious economic implications for the fishing industry and sport, meteorological consequences such as the phenomenal warmth of air temperatures in coastal areas have occasionally been attributed to the warmer than normal sea surface. However, one might ask to what extent the atmospheric circulation contributed to these abnormal temperatures at coastal cities. Let us consider San Francisco as an example and Fresno for contrast.

It is well known that upper level ridges are usually associated with above normal temperatures along the West Coast because of subsidence and heating aloft, as well as the warm origin of the air from the south and increased sunshine. The magnitude of the warming effect is roughly proportional to the long period average anomaly of the height of

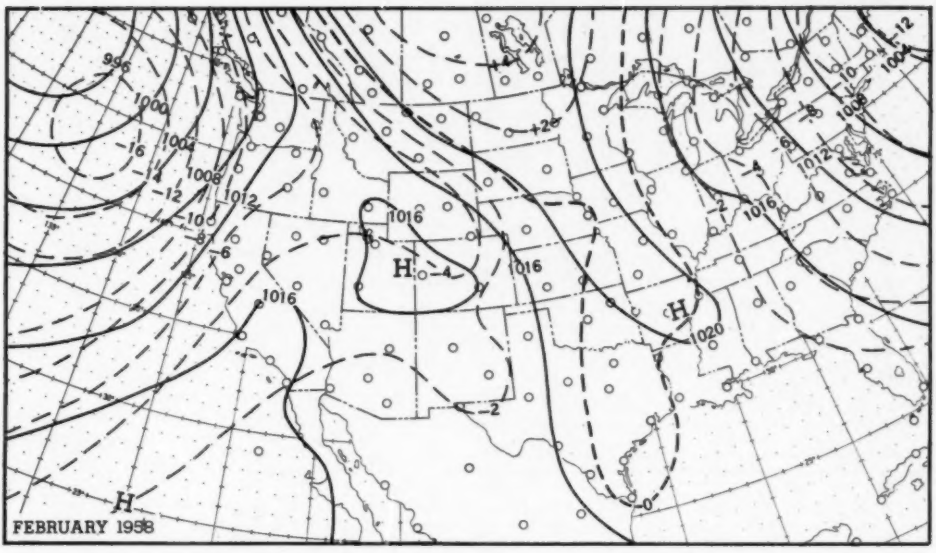


FIG. 1. Average sea level isobars (solid) and departures from normal (dashed) both in millibars, for Feb. 1958. The isopleths of departure indicate that the southerly flow near the west coast of the U. S. increased about 80%.

the upper pressure surface at about 10,000 ft. (e.g., 700 mb) used to portray characteristics of the general circulation.

The 700-mb height for the year averaged about 37 ft. higher than normal at Fresno and 32 ft. at San Francisco, indicating that the overall effect of the general circulation was for warming at both cities. However, the surface temperature anomaly at San Francisco airport averaged + 4.5° F compared with + 0.7° F at Fresno for the year. Considering that Fresno is much less influenced by the ocean, one might hastily conclude that the large excess of warming at San Francisco was due to the ocean warmth. To throw some light on this question the graphs in figures 2 and 3 were prepared to show the variation in the monthly 700-mb height anomalies in comparison with the monthly temperature anomalies at both cities. In addition the variation of monthly sea surface temperature anomalies at San Francisco (Fort Point) supplied by the Coast and Geodetic Survey, has also been plotted for comparison (fig. 2).

Except in February, the 700-mb height and surface air temperature anomalies at Fresno (fig. 3) closely correspond, suggesting that the major control of temperature at Fresno during 1958 was the broad scale atmospheric circulation. In February (fig. 1) the abnormal flow of the circulation affected Fresno in much the same way as San Francisco, i.e., strong warm advection due to the abnormal southerly flow overcompensated the decreasing height anomaly aloft.

At San Francisco, however, there were sometimes marked inverse variations between the monthly 700-mb height and surface temperature anomalies, especially in February, September, and October (fig. 2). In February an abnormally deep center of cyclonic activity which had dominated a large part of the Pacific throughout January drifted closer to the West Coast, producing extremely strong southwesterly flow (fig. 1) and advection of warm air from lower latitudes. It should be observed that the sea water temperatures along the West Coast often respond in the same fashion as air temperature due to persistent transport of normally warmer surface waters toward the coast and also due to the reduced upwelling of colder water from below. In fact, the spectacular rise in ocean level near the cost during January and February,

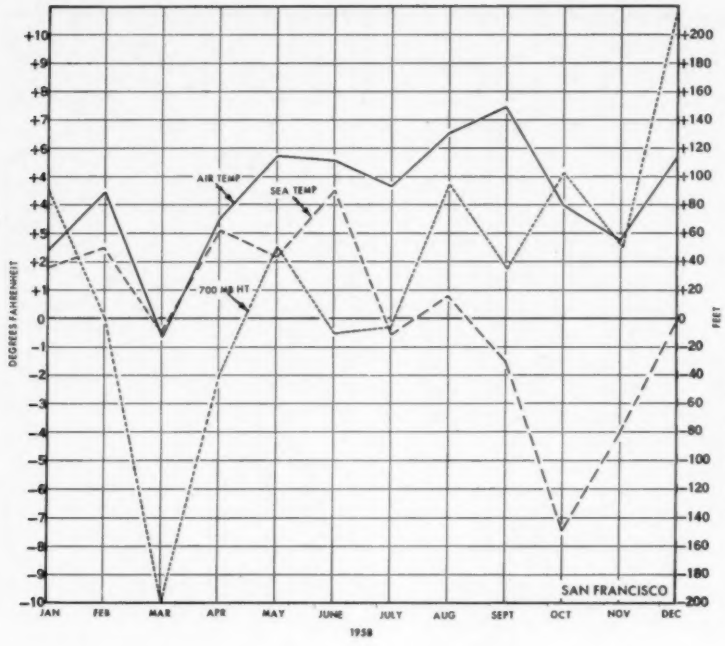


FIG. 2. Monthly average anomalies of air temperature (solid), coastal water temperature (long dashes), both in degrees F, and 700-mb height in feet (short dashes) at San Francisco for 1958.

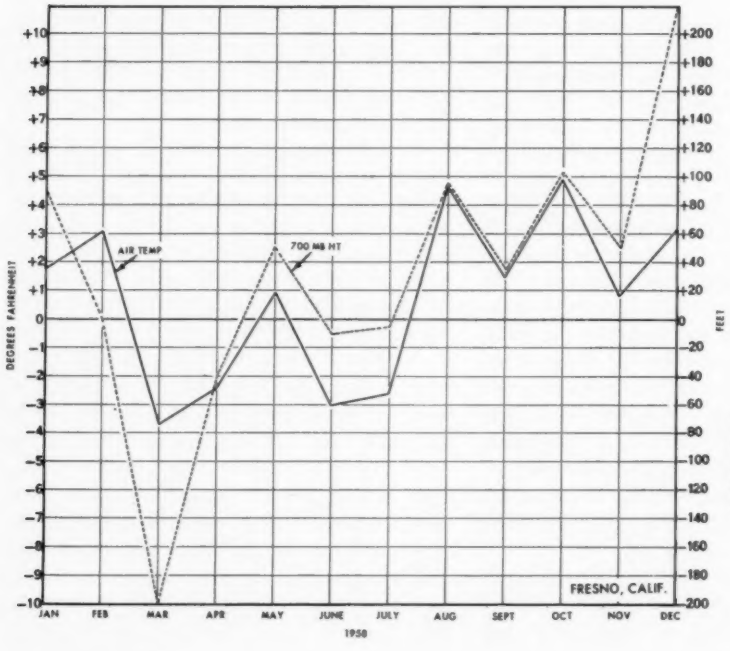


FIG. 3. Monthly avererage anomalies of air temperature and 700-mb height at Fresno for 1958. Legend same as in figure 2.

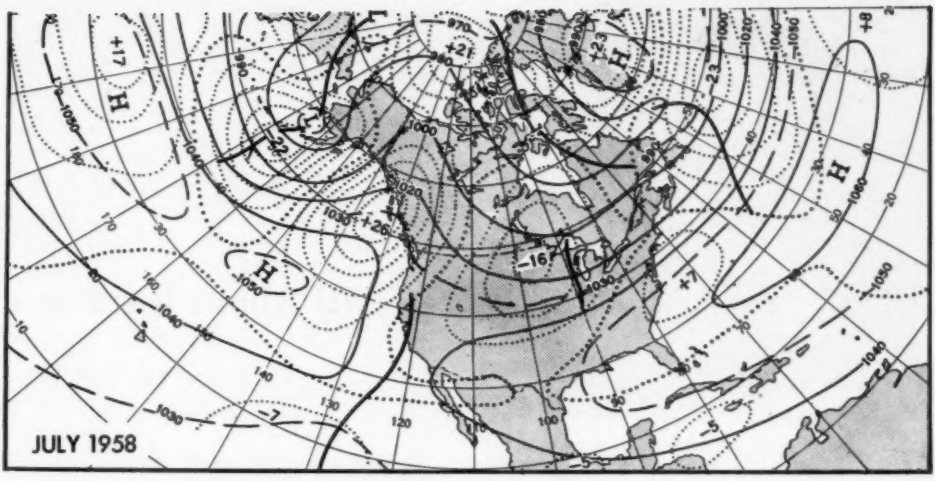


FIG. 4. Monthly average 700-mb contours (solid) and anomalies (dotted), both in tens of feet, for July 1958. The strong positive height anomaly near the coast of British Columbia was associated with the hottest July on record in the Pacific Northwest.

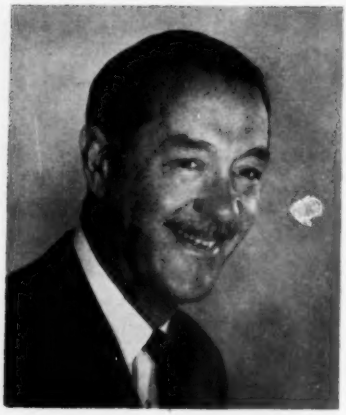
mentioned above, was believed caused by this same mechanism. Thus it appears that both abnormally warm sea water and air temperatures were produced by the same abnormal atmospheric flow.

July was another contrary month at San Francisco airport (fig. 2) in that the 700-mb height anomaly and sea water anomaly were both slightly below normal yet the abnormally warm air temperatures persisted, averaging 4.7° F, or over 3 standard deviations above normal, while Los Angeles airport's air temperature anomaly decreased to 0.3° F above normal and San Diego 0.7° above normal. San Francisco's air warmth is at least partially explained by figure 4 which shows northeasterly anomalous flow out of the hot Pacific Northwest due to the strong large scale ridge in the general circulation dominating that area, while Southern California was largely unaffected by this mechanism.

The other two unusual months at San Francisco, in terms of the inverse variation of temperature and 700-mb height anomalies (fig. 2), were September and October. In September, despite a decrease in the 700-mb height anomaly and a decrease in the coastal sea-water temperature to below normal, San Francisco experienced its warmest month in 88 years of record, 7.5 degrees or 5 standard deviations above normal at the airport. Approximately the same conditions occurred at Los Angeles and San Diego. This phenomenal warmth appears to be associated with persistently recurrent offshore flow during the month. For example, the average sea level map for September, with the departures from normal superimposed (fig. 5), indicates an average anomalous easterly component of about 6 knots over California. This reflects recurrent intrusions of high pressure into the northern Plateau during the month with frequent easterly flow, transport of relatively hot air from the interior toward the coast, and with some foehn. The surface wind speeds for the month at San Francisco also reflect this condition, with resultant westerly winds averaging 0.2 m.p.h. below normal at San Francisco airport and 1.2 m.p.h. below normal at the Federal Building.

October was similar but with the direction of anomalous flow at sea level from the southeast rather than east as in September. Thus the transport of hot air from the interior was reduced but increasing ridge conditions in the circulation aloft with attendant subsidence and increased sunshine helped to maintain temperatures well above normal.

(*Continued on page 61*)



All About Humiture

OSBORN FORT HEVENER

TWENTY–TWO years ago, I was fortunate enough to coin two words that have found their way into the dictionaries, and to develop a concept that has proven useful and popular. To let the secret out, I am the *humiture* man. Some persons have been surprised to learn that my "mundane" existence involves an executive position with The First National City Bank of New York. So my story may interest you, as I hope will the ideas that I take this welcome opportunity to express.

I have been following the weather and studying weather lore ever since I was a schoolboy; and I cannot vouch for the authenticity of the family tradition that my first infant cry sounded like "humiture," but I offer it to confirm my claim to being a veteran weather fan. I was put into circulation with the "coinage" of 1899 and I have been faithful to my native state of New Jersey, after a fashion, because I have been com-

(*Continued on page 83*)

rm | **a'tion**, *n.* —Syn. humble, mortify, chagrin.
ren **hu·mil·i·ty** (hū·mil'ə·tī), *n., pl.* **–ties.** **1.**
ies humbleness of mind; meekness. **2.** Usually, **hu-**
ore **milities.** act that shows a humble spirit. —Syn.
to **1.** lowliness, modesty.
do **hu·mit** (hū'mit), *n.* unit of measurement used
lo: in expressing humiture. If the temperature is 80°
er- and relative humidity is 60%, the humiture is 70
n. humits. [< *humiture*]
ul; **hu·mi·ture** (hū'mə·chər), *n.* a combined meas-
nd urement of temperature and humidity, arrived at
u- by adding degrees of tem-
1. perature to percentage of
el. relative humidity and di-
em viding by two. [< *humi-*
an (*dity*) + (*tempera*)*ture*;
e- coined by O. F. Hevener of
of New York in 1937]
ad **hum·ming·bird** (hum'-
of ing·bėrd'), *n. Am.* a very
ad small, brightly colored
lj. American bird with a long,
narrow bill and narrow

Hummingbird
(ab. 3¾ in. long)

The Thorndike-Barnhart Dictionary 1957.

The Discomfort Index

E. C. THOM,
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U. S. Weather Bureau,
Washington, D. C.

U. S. Weather Bureau climatologists, Earl C. Thom (left) and J. F. Bosen with sling psychrometer, discuss Discomfort Index data. Photo courtesy Washington *Star* and U. S. Weather Bureau.

THERE is a long recognized need for a generally acceptable "cooling-degree-day" system for the air conditioning and allied industries. In an attempt to meet this need, some years ago the Weather Bureau with WPA assistance compiled long-term monthly and seasonal average cooling-degree-day values for over 200 locations. In this compilation the cooling-degree value for any day was the number of degrees that the mean dry-bulb temperature exceeded 75°. Serious objections to this idea, which ignored the moisture content of the air, developed as the work progressed so that, although the project was completed, the results were never published.

A number of operating utilities and many operators of large air-conditioning installations have developed plans by which they set up some measure of the cost of electric current required for air conditioning under various weather conditions. Unfortunately these plans differ widely. One company, for example, has a cooling-degree-hour system which utilizes "effective temperatures" (1) secured from simultaneous hourly dry-bulb and wet-bulb readings and taking effective temperature of 71° as the base; another company has a cooling-degree-day system which is based on the excess of the mean dry-bulb temperature for each day over a base of 65°; another company uses the excess of one-third the daily average dry-bulb temperature plus two times the corresponding wet-bulb value over a selected base value; and another company has found an answer in the excess of the average of the daily mean dry-bulb and wet-bulb values over a base of 57½°.

The last plan mentioned above has been tested for several years with a large number of air-conditioning installations. Except in the higher ranges, the average of a pair of simultaneous dry-bulb and wet-bulb readings has a rather close relation to the effective temperature obtained from the same pair of readings. Effective temperatures have been accepted for some years as the best available measure of human comfort. Effective temperatures, therefore, would serve to indicate the amount of human discomfort and the resulting need for air conditioning; they could also be utilized to indicate the increase in the operating load attributable to air-conditioning installations. Effective temperatures, as such, are not easy to secure from currently observed data, and for practical purposes effective-temperature normals cannot be secured from the existing punched cards which record the weather conditions of past years.

Study of the problem has developed a useful tool, which we have called the "discomfort index." This index is secured by a sim-

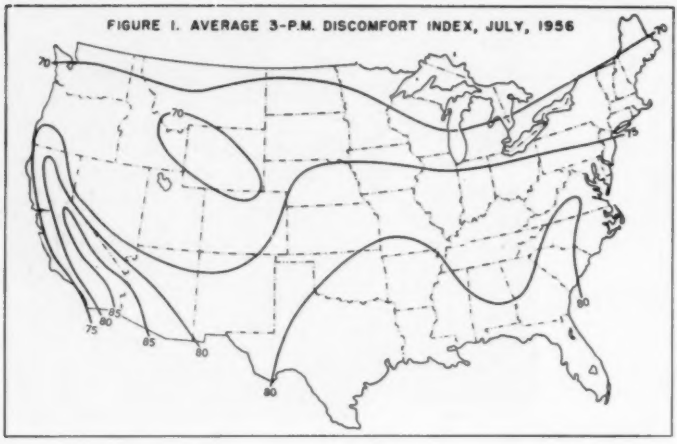
FIGURE 1. AVERAGE 3-P.M. DISCOMFORT INDEX, JULY, 1956
70
70
70
75
75
80
85
80
85
80
80
80

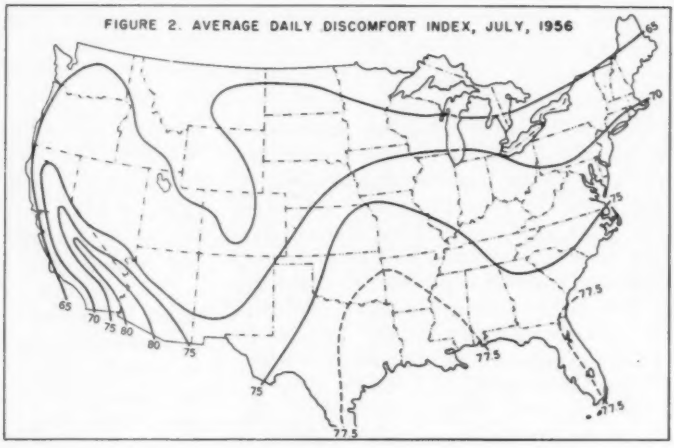
FIGURE 2. AVERAGE DAILY DISCOMFORT INDEX, JULY, 1956
65
70
75
80
80
75
75
77.5
77.5
77.5
77.5

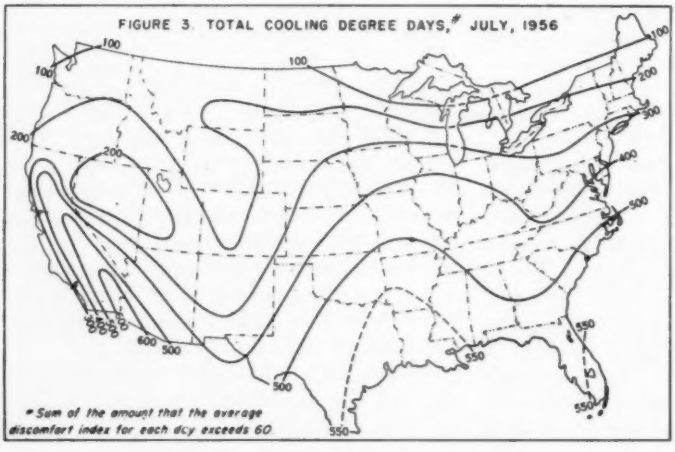
FIGURE 3. TOTAL COOLING DEGREE DAYS,* JULY, 1956
100
100
100
200
200
300
400
500
500
550
550
550
600
500
500
550
* Sum of the amount that the average discomfort index for each day exceeds 60

ple linear adjustment applied to the average of the dry-bulb and wet-bulb readings.

$$DI = 0.4\ (t_d + t_w) + 15$$

All t values are in degrees F, and the t values are simultaneous readings. This adjustment has brought the index into reasonably close agreement with effective temperatures over all the recorded ranges of dry-bulb and wet-bulb values. The index gives us a good idea of the degree of discomfort. People feel discomfort as the index rises above 70, with over half uncomfortable with the index over 75. Everyone will be uncomfortable by the time the index reaches 79, most people feeling the discomfort acutely by this time. As the index passes above 80 discomfort becomes more serious. When office conditions in the Washington Metropolitan area are such that the index becomes 86 or higher, for example, present government regulations permit supervisors to give consideration to the mass dismissal of the employees who are working under these conditions.

An examination of the published, hourly observations made at selected stations during July 1956 shows the following largest discomfort index at various stations during the month: 89 at Yuma, Ariz., and Dallas, Tex.; 86 at Phoenix, Ariz., and Evansville, Ind.; 85 at Sacramento, Calif., and Lexington, Ky.; and 84 at Las Vegas, Nev., and Indianapolis, Ind. The 89 index was the highest noted in the United States during this month. The same degree of discomfort is caused by quite different conditions as is shown by the 84 index at Las Vegas where a dry-bulb temperature of 107° and a wet-bulb of 69° (relative humidity 13 per cent) were recorded while at Indianapolis with the same index the corresponding temperatures were 93° and 80° (relative humidity 57 per cent).

Consideration has been given to the discomfort index as a basis of a cooling-degree-day system. During the trial period the plan is being tested using a discomfort-index value of 60 as the base. The number of "cooling-degree days" credited to any day under this plan is the excess of the average of the 24-hourly discomfort-index values over the base 60, and the total cooling-degree days for the month are the accumulation of the cooling-degree-day figures for each day of the month.

Several applications of these basic ideas are shown in the accompanying table and figures. Figure 1 gives in isoline base-map form the distribution of the average 3 p.m. (local time) discomfort-index values for July 1956. Figure 2 gives in a similar manner an approxi-

TABLE 1

TOTAL COOLING DEGREE DAYS FOR SELECTED STATIONS, 1956

Station	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
Seattle	0	0	0	0	28	19	130	93	27	0	0	0	297
Boston	0	0	0	0	20	206	282	251	71	15	7	0	852
Hatteras	0	0	0	66	167	399	530	481	353	232	52	47	2327
Chicago	0	0	0	11	100	310	358	326	103	46	0	0	1254
Atlanta	0	12	21	65	287	380	483	450	249	116	19	28	2110
New Orleans	26	102	121	195	426	450	570	527	420	310	115	85	3347
Sault Ste. Marie	0	0	0	0	0	83	65	105	8	5	0	0	266
Miami	124	261	256	323	473	488	577	558	435	458	241	252	4446
Kansas City	0	0	0	36	227	390	490	457	225	110	20	0	1955
Billings	0	0	0	0	58	173	264	153	54	0	0	0	702
Amarillo	0	0	0	0	147	383	400	318	203	60	0	0	1511
Brownsville	129	189	239	343	457	488	547	558	465	411	156	95	4077
Yuma	0	0	58	113	303	480	639	543	570	240	28	0	2974
San Francisco	0	0	0	0	12	34	50	48	71	9	0	0	224

mation of the 24-hour average of the index values for the same month. Figure 3 gives the distribution of the total cooling-degree days for the sample month of July 1956. Table 1 gives a useful approximation of the total cooling-degree days under this system for 14 selected stations for each month and for the full 12-month period from January 1956 through December 1956. Values in table 1 were secured by averaging the observations published in the Weather Bureau's *Local Climatological Data Supplement* for the four synoptic hours (1 a.m., 7 a.m., 1 p.m., and 7 p.m., e.s.t.). It follows that there is some variation from what would have been shown had the 24-hourly observations for each day of the period been used. Figures 2 and 3 are based on computations using the averages of index values secured from the 5 a.m., 10 a.m., 3 p.m., and 10 p.m. local-time observations. Observations at these four selected hours have been found to give a good approximation of the entire 24-hour period.

This cooling-degree-day concept must be tested over one or more cooling seasons. It will then be possible to determine how closely the total, currently computed, cooling-degree days correlate with the corresponding load which air-conditioning installations produce. If the proposed system proves satisfactory when tested, the next step will be to have cooling-degree-day normals computed from hourly observations by machine processing of the existing punched-card data. It would then be possible to publish cooling-degree days with departure from normal for each Weather Bureau Office.

The Office of Climatology has furnished Weather Bureau stations throughout the country with the necessary information to compute the discomfort index. This summer will mark an experimental period during which local offices may make public the daily discomfort index data if their other work permits this and there is a public demand for the information.

REFERENCE

1. The 1956 edition of *Heating, Ventilating, and Air Conditioning Guide* defines effective temperature as: "An arbitrary index which combines into a single value the effect of temperature, humidity, and air movement on the sensation of warmth or cold felt by the human body. The numerical value is that of the temperature of still, saturated air which would induce an identical sensation."

A High School Weather Program

The State of Pennsylvania has initiated steps that will lead ultimately to the establishment of a weather station in every high school in the state. The Department of Public Education recently acted to meet the opportunity presented by the National Defense Education Act of 1958, which over each of the next four years will provide the states with $70 million. Most of this sum will annually be ear-marked for the purchase of equipment to further instruction in the fields of science. Allotments will be made to the states on a matching fund basis, so that local sources will contribute one-half toward the purchase of new equipment.

The Pennsylvania Department of Public Education has already drawn up recommendations for a new course to replace the traditional general science course. It will be entitled Earth and Space Science and will include instruction in the fields of geology, meteorology, and astronomy. Most schools will conduct it at the 9th grade level, though a few have indicated that an advanced 12th grade course will be offered.

Recommendations for the purchase of equipment have already been formulated, and a syllabus is being prepared for issue in June. The weather stations will include standard Weather Bureau climatological equipment: max-min thermometers, sling psychrometer, rain gage, and shelter. Remote-reading, indicating wind equipment is also recommended along with a recording barometer.

Philadelphia's well-known TV weatherman, Prof. Francis Davis of Drexel Institute, an AMS member, has served on the special committee to formulate plans for this important project.

Pacific Coast (*Continued from page 55*)

Summary

As can be seen in figure 2, coastal water temperatures near San Francisco averaged well above normal in the first half of the year but declined sharply around midyear, averaging below normal for the latter half year. For the year as a whole water temperatures averaged near normal. Thus neither the general circulation height anomalies nor the coastal water temperatures are in themselves capable of explaining the degree of the abnormal warmth during 1958. The primary factor in this warmth along the California coast seems to have been a recurrence of abnormal patterns of atmospheric flow, from the warm ocean to the southwest in the cold season, and from the heated land in the warm season. Both the air temperatures and sea water temperatures in coastal areas responded to some extent to these persistent atmospheric motions. Particularly in the first half of the year when the air flow was predominantly onshore, the warmer waters must have made a contribution. But in the latter half of the year the water temperatures appear to have played a lesser role.

Other areas of the West Coast may have been influenced to a greater degree by warm waters or the circulation anomalies. It seems safe to say, however, that persistent patterns of abnormal atmospheric flow played a major role in these areas also.

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3. H. B. Stewart, B. O. Zetler, and C. B. Taylor, "Recent Increase in Coastal Water Temperatures and Sea Level California to Alaska," U. S. Coast and Geodetic Survey, *Tech. Bull. No. 3*, May 1958.

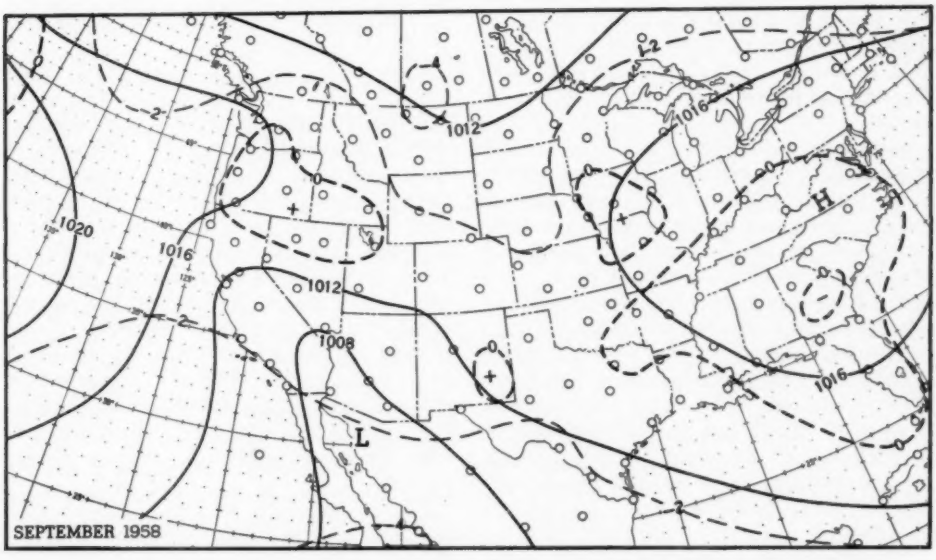


Fig. 5. Average sea level isobars (solid) and departures from normal (dashed) both in millibars, for September 1958. The persistent easterly flow from the warm southern Plateau produced the record-breaking heat wave along the California coast.

Weather Rambles

IVAN W. BRUNK
U. S. Weather Bureau
Chicago, Ill.

ANOTHER BLIZZARD OF 1888

ONE of the most destructive blizzards on record in the Northern Plains occurred on 12 January 1888. This blizzard has been called Omaha's "biggest news event," and one of the most spectacular occurrences in Nebraska's history. Many lives were lost in the blizzard and much livestock perished. It was reported that cattle were frozen to death in a standing position and to this date there is no accurate record of the number of lives lost in this blizzard. In 1888 there were few daily papers and no radios or rural telephones. Due to the disrupted transportation and lack of communication, the first newspaper accounts made a joke of the effect of the storm, and it was not until days after the blizzard that the full impact was realized. Estimates of the number of deaths range from several hundred to a thousand. Settlers in those days were few and far between and they could not be spared.

Settlers in the Northern Plains in 1888 were pioneers, and sod and log houses and schools were common. The blizzard came without warning and many people were caught away from shelter, especially since the weather preceding the blizzard was unusually warm. The blizzard pushed southeastward across Montana into Dakota and Nebraska with the most destruction in the area which is now South Dakota. It caused temperature fall from 30 to 60 degrees in 24 hours with readings down to 20° to 40° below zero. Although the snowfall was comparatively light, the strong winds picked up what was on the ground and piled it into drifts which ranged from 5 to 20 feet deep.

The blizzard came upon much of the region during the daylight hours, when many of the pioneers were away from shelter. Many of those who perished were school children. Some were caught going home and others left school after all combustible material had been burned, only to be frozen before reaching nearby shelter. There were many stories of heroic actions by teachers who saved the lives of their school children. Many such tales are related in a book called "In All Its Fury," an account of the blizzard of 1888. This was published in 1947 as a result of interest created after the organization of the "January 12, 1888 Blizzard Club" by survivors of the blizzard.

Although there have been cold waves with lower temperatures, snow storms with heavier snow, and blizzards with higher winds, the combination of gale winds, blinding snow and an extremely rapid temperature drop makes the blizzard of 12 January 1888 one of the most notable on record.

ARTIFICIAL SNOW

Skiing enthusiasts this year, who may encounter colored snow in solid shades, or in stripes and even polka dots, will not just be "seeing things," but will be looking at snow which is not only colored but also artificially produced. Man-made snow is now being produced at an increasing number of ski areas when it is necessary to augment the natural snowfall. The operation is not one of simply crushing ice, but is actual artificially produced snow. Most of the artificial snow is white and is made to cover existing snow or even bare ground. This makes skiing possible when conditions would not otherwise be favorable.

The machines, over an area roughly 300 by 500 feet, produce supercooled water droplets which fall as granular or flake type snow, depending upon temperature and wind conditions. The ability to control snow type and rate of accumulation still depends upon

favorable assistance from nature, but moisture and proper distribution for specified areas can be manually controlled.

Ideal operating conditions call for a free air temperature of 15°–20° and very light or calm winds. When needed, snow can be produced as soon as the temperature drops to 28°. While in operation a temperature rise to 32° may change the type but not the production of new snow. The snow can be varied in type from powder to slush, depending upon the operation and the prevailing natural weather conditions.

Snow cover can be built over any frozen surface but accumulations are more rapid when started over a base of natural snow. Operating on 110–130 pounds of air pressure and around 70 pounds of water pressure, the snow machine can cover an entire slope with a new snow cover in a matter of hours. Dye can be used in the water system to produce colored snow if desired.

Clouds and Heating Bills

Fuel bills in many areas would be considerably higher if it were not for clouds. Clouds have a marked effect upon nighttime temperatures during the winter months, especially if the winds are light and there is considerable snow on the ground. The presence or absence of clouds during the long winter nights under such conditions, may make a difference of 20 degrees or more in the minimum temperature during the night. The clouds act like a blanket and help to prevent the loss of heat to outer space from the snow-covered surface. In the absence of an overcast, the snow surface radiates outward strongly, thus lowering the temperature of the snow surface and the air in the lower layers of the atmosphere. Therefore, other things being equal, the temperature is usually considerably higher in the winter during cloudy nights than on clear nights.

During cloudy conditions in winter, there is usually little variation between nighttime and daytime temperatures, and clouds in the daytime in winter may also keep the temperature from rising as high as it otherwise would. However, this does not make as much difference in temperature as the nighttime effect, because of the short winter days. Snow on the ground is also effective in keeping the temperature from rising during the day, since the insolation is to a large extent reflected so that the snow can absorb little heat.

Clouds also have an important effect upon temperatures in the summer, but this is principally in the daytime, when the summer days are much longer than the nights. In the summer the presence or absence of clouds during the day may have as much effect upon temperatures as the nighttime effect of clouds in the winter.

Snow Rollers

Snow appears in many forms—from the small flakes that delight young children and lead to forecasts like: "Snow tonight, followed by little boys on sleds," to the heavy blanket of snow of the traditional "White Christmas." Snow brings joy to winter sports enthusiasts, but is a bane to motorists and pedestrians. One rarely observed form of snow is natural snowballs, technically called "snow rollers."

Snow rollers are masses of snow shaped like a lady's muff. They vary in size from very small cylinders to some that are 7 feet in circumference and 3 or 4 feet in length. They usually develop in mountainous or hilly regions when the snow is moist enough to be cohesive, with temperatures a little above freezing. A snow roller forms when the wind blows down a slope, picking up some wet sticky snow, and rolling onward and downward until it either becomes too large or until the slope of the ground changes too much for the wind to propel it farther. Many rollers end their journey by flopping over on their sides. Snow rollers are similar to those which small boys use in making snow men, but in this case the wind takes the place of the small boys. The area cleared of snow during the formation of snow rollers is usually V-shaped, accounting for their peculiar shape, which is cylindrical with concave ends.

While snow rollers are rather rare in the Middle West, a number formed at Aurora, Illinois, on 7 January 1957. At the time of development, snowfall in Aurora was quite light, but temperatures and wind conditions were very favorable. The snow rollers formed on nearly level ground. Most were quite small, but a few were around a foot in diameter.

FIG. 1. The eye of Typhoon Kit, with spiral bands and secondary vortices; 14 November 1957, north of Luzon.

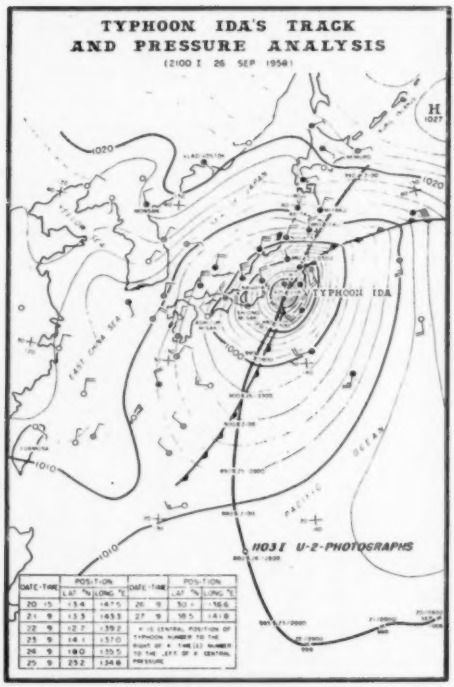


FIG. 2.

Typhoon-Eye Cloud Pattern

ROBERT C. BUNDGAARD, ROBERT D.
Air Weather Service,

PRESUMABLY, one of the greatest immediate benefits of meteorological satellites will consist of presentations of large-scale cloud patterns of meteorological phenomena for use in weather forecasting and research. It is contemplated that patterns ranging in size from single convective-cloud developments to the collective cloud configurations of frontal systems will be recorded and placed at the disposal of the meteorologist.

In particular, it has been suggested that satellites will locate the centers of typhoons and hurricanes. Information as to the latitude and longitude of the eye of a storm, the character of the clouds in the vicinity of the eye and in the spiral bands surrounding it, and time changes in the cloud patterns, will be of tremendous assistance to the forecaster concerned with estimating the future position and extent of the storm. It will also be of great economic value to typhoon-reconnaissance people who no longer will have to search wide areas in locating a possible storm; but, instead, can direct aircraft to the exact location of the center to probe its lower regions for the wind, pressure, temperature, and precipitation data which probably will be beyond the measuring capabilities of satellites for some time to come.

The patterns of low-level winds and pressures in tropical cyclones are well known to meteorologists. So, too, are the cloud and precipitation distributions as determined by radar and by aircraft flying inside the various sectors of the storms. The important question has been raised, however, as to whether typhoons and hurricanes are really identifiable from above—from the vantage point of the satellite.

The National Aeronautics and Space Administration, with the support of the Air Weather Service, since 1957 has been conducting an upper-air research program in Japan for the purposes of testing new and improved types of meteorological sensing equipment and collecting high-altitude meteorological data. The equipment includes a

atterns as Viewed from Above

OBERT D. FLETCHER, JAMES R. SMITH
Service, U. S. Air Force

Perkin-Elmer Model-501 tracking camera to record cloud patterns on 70-mm film. The equipment is mounted in a U-2 jet aircraft capable of flying at heights up to about 10 miles above sea level. Since November 1957 the aircraft has been able to fly over the tops of three separate typhoons and to photograph the cloud patterns of the centers. In each of the three cases the individual photographs have been fitted together into a mosaic showing the configuration of the clouds over the entire eye.

The first flyover, the details of which have been reported by Bundgaard, occurred on 14 November 1957 over Typhoon Kit just north of the Philippine island of Luzon. See *Weatherwise*, June 1959. Clearly evident was the general pattern of the clouds spiraling into the center, as was the location of the eye, itself. In the case of Kit, there appear to be several additional cyclonic whirls of which Bundgaard has identified eight.

On 9 July 1958 the Air Weather Service's 54th Weather Reconnaissance Squadron, under Lt. Colonel Dale Desper, noted on its synoptic charts a "suspicious area" about 300 miles northwest of Yap Island. The area was reconnoitered by WB-50 aircraft and by 11 July a full-fledged storm, Typhoon Winnie, was located. During the ensuing four days 13 penetrations at 500 mb were made into the center of the storm. On the 15th the typhoon entered Formosa—the most destructive such storm, for the island, of the past decade. Several hours before it reached the east coast of Formosa a U-2 aircraft was dispatched to the storm. It found it could top the clouds of the storm and did so, taking the pictures which form the mosaic shown in Figure 1. In overflying the storm the pilot reported a completely smooth ride, which was quite in contrast to the flights made some six or seven miles lower by the WB-50's which encountered severe turbulence. The eye was a large one; the typhoon winds of its circumference lashed the entire island. The photograph is of the eye itself with the wall clouds

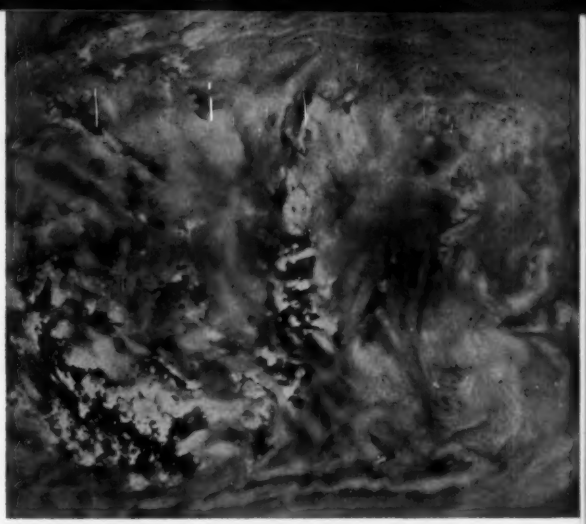


FIG. 3. The eye of Typhoon Winnie, with "wall" clouds discernible at edges of photograph; 14 July 1958, east of Formosa.

discernible in the very corners. The cloud pattern of the eye is very chaotic with two distinct layers clearly evident, one low and the other probably at cirrus levels. The photograph does not show the solid sheet of cirrus surrounding the eye. As described by the pilot there was no detail to this cirrus-cloud cover—only a "solid mist which extended to all horizons."

Typhoon Ida developed near the Mariannas on 21 September 1958. On the 22d it curved northward and passed over the Tokyo area near midnight of the 26th. When it was just south of Japan its central pressure reached a reported minimum of 877 mb and the maximum recorded wind was about 140 knots. It was a devastating storm which produced, incidentally, record-breaking precipitation in the Tokyo area. In Figure 2 is shown the track of the typhoon as well as its pressure pattern as it was approaching the island of Honshu. On the morning of the 24th a U-2 aircraft reconnoitered the typhoon. As in the cases of Kit and Winnie, the aircraft found it could clear the cloud tops of Ida and locate the eye of the storm. It made a succession of passes over the eye, the pilot reporting a smooth flight as was the case with Winnie.

The photograph of Ida's eye is shown on the front cover. Here there is no question as to the general circularity of the eye; in this particular picture there is only a suggestion,

however, of the spiral cloud bands. The photograph shows a chaotic deck of broken low clouds in the eye with no middle or high clouds except, perhaps, for a few cirrus wisps protruding inward from the north. From the top of the low clouds to the top of the cirrus is estimated to be five to seven miles. The sun's reflection from the side of the cloud wall and top of the low clouds is quite bright—considerably more so than is apparent from the amorphous cirrus of the surroundings. The brightness within the eye is consistent with reports of typhoon-reconnaissance meteorologists who say that they are often blinded upon breaking through the wall of the eye. It also suggests that the excessive reflected radiation may in part account for the abnormally high temperatures frequently reported in the eye of a typhoon or hurricane.

From the three flyover photographs considered in this paper a few tentative conclusions can be drawn as to future satellite observations of typhoons and hurricanes:

1. Usually, although not necessarily always, the spiral structure of the clouds around the eye will aid in locating the center.
2. Usually the eye itself will be identifiable, although at times the existence of secondary vortices will require study by a trained analyst.
3. Usually there will be clouds within the eye; they will be chaotic and broken, with patches of sea surface visible; usually they will be low and often there will be no high clouds.
4. At certain times of the day, and with a center essentially free of high clouds, the eye may appear to the satellite to be a circular region of maximum brightness imbedded in a large area of not-so-bright cloud cover.

Much study is required to determine the optimum resolution for pictures taken from a satellite. Certainly a resolution of one mile and probably one of five miles will suffice for identification of the great majority of hurricanes and typhoons, but a resolution of 50 miles will probably hide the detail necessary for distinguishing the eyes and spiral cloud patterns. Further overflies will be made and more detailed data will be collected to assist in answering this and other important meteorological questions. In an overall sense, the over-the-top photographs of Kit, Winnie, and Ida indicate that cloud structures of hurricanes and typhoons are such as to make the satellite an excellent reconnaissance vehicle for their detection and location.

REFERENCE

Bundgaard, Robert C.: The First Flyover of a Tropical Cyclone. *Weatherwise*, Vol. 11, No. 3, pp. 79–83; June, 1958.

Weather Modification

A program for research in weather modification was recently announced by the National Science Foundation. The program, which will expend the sum of $1.1 million in 1959–60, will consist of 13 grants for laboratory research, field experiments, evaluation of present theory and practices, and conferences on modern meteorological methods directed toward weather modification. Many AMS members, as well as AMS corporation members, will participate in the varied phases of this project whose objective is to carry on a full range of field and laboratory experimental work coordinating the techniques of physics, chemistry, and mathematics.

Atmospheric Science

The Alfred P. Sloan Foundation has granted $45,000 to the University Committee on Atmospheric Research to encourage graduate study of meteorology and closely allied sciences. Ten fellowships for the academic year 1959–60 have been awarded. Recipients will each receive $4,000 and may attend any qualified institution offering a graduate program in the sciences of the atmosphere. Many capable and well-trained scientists from all fields will be required to man the greatly expanded research effort that is now being planned in the atmospheric sciences.

IGY Special Studies in Meteorology

The following report is based on material supplied by Sigmund Fritz, Lester Hubert, P. A. Humphrey, R. J. List, T. W. Machta, T. H. McDonald and W. B. Moreland, U. S. Weather Bureau; C. D. Keeling, Scripps Institution of Oceanography; R. G. Leahy, Woods Hole Oceanographic Institution; and E. R. Ibert and D. W. Hood, Texas A. & M. College.

THE IGY prompted an increase in the U. S. Weather Bureau's extensive program of standard meteorological measurements of temperature, pressure, wind speed and direction, precipitation, etc. In addition, the U. S. Weather Bureau also conducted a series of special meteorological studies during the IGY. These dealt with incoming and reflected solar radiation; ozone, CO_2, and other atmospheric constituents; nuclear "tracer" materials in the air; and aerial meteorological reconnaissance in tropical regions.

This report summarizes the aims and some of the findings to date of these investigations.

Solar Radiation

The geographically uneven absorption by the earth and its atmosphere of radiative energy is a major cause of the general atmospheric circulation. From the tropics to the middle latitudes, more solar radiation is absorbed than is lost by re-radiation; poleward from these latitudes more radiation is lost than received. The resulting net warming in the tropics and net cooling in polar regions motivate the global circulation.

Our knowledge of solar energy, absorption and re-radiation, and of radiation exchanges in the atmosphere, has been quite limited. In general, visible and short-wave solar radiation penetrates the atmosphere to the earth's surface, where it is absorbed and radiated again in long waves, mainly in the infrared region of the spectrum. Water vapor, CO_2, and ozone in the air absorb most of the out-going infrared radiation and return it once again to the earth. As part of the IGY program, the U. S. Weather Bureau measured solar radiation and long-wave radiation at six stations in Antarctica and on two drifting ice stations in the Arctic Ocean. The Wilkes Station in Antarctica also had a sub-station on the inland ice 50 mi. to the east-southeast at an elevation of about 3,700 ft. Similar measurements were taken at a newly-established observatory 11,150 ft. above sea level, at Mauna Loa, Hawaii (19°N, 155°W).

The elements measured were the intensity of total solar and sky radiation on a horizontal surface, intensity of the direct solar beam, natural illumination, albedo, or reflectivity, of the earth's surface, hemispherical radiation (from above), and net radiation (incoming minus outgoing). The solar beam appears to be depleted to a much smaller extent in the Antarctic and at Mauna Loa, where the atmosphere is purer, than at the two continental United States stations.

Studies at Drifting Station Alpha in the Arctic Ocean (see IGY *Bulletin No. 12*) indicate the great importance of long-wave radiation from the overcast sky in the melting of snow and ice. During the melt season, melting proceeds much more rapidly under the overcast than it does with clear skies and bright sunshine; with clear summer skies, in fact, refreezing may occur.

Ozone

The ozone concentration in the earth's atmosphere increases vertically, reaching a maximum in a layer which may lie between heights of about 12 and 22 mi., depending on time and latitude. The amount of ozone in any vertical column in the atmosphere varies with changes in the atmospheric circulation. Hence, measurements of the distribution and variations of ozone at the surface and in the lower levels of the atmosphere provide clues to the vertical and horizontal motions of the lower stratosphere. Moreover, ozone is thought to be responsible for the large annual temperature variation in the stratosphere above the polar regions.

Ozone measurements were made by the Weather Bureau during the IGY at stations in the continental United States, in the Arctic and Antarctic, and in Hawaii. Prior to the IGY, ozone measurements for the Antarctic were completely lacking.

Surface Ozone at Mauna Loa, Hawaii: Continuous recordings of surface ozone at the Weather Bureau's Mauna Loa Observatory have been made since August 1957 with automatic chemical sampling equipment developed by V. H. Regener at the University of New Mexico.

The first 14 months' records indicate that the variations in surface ozone at Mauna Loa are related to both local and large-scale features of the atmospheric circulation.

A marked seasonal variation is evident, with a spring maximum and an autumn minimum of surface and total ozone similar to those found elsewhere. Monthly means ranged from 33 micrograms/m³ in October 1957 to 68 in April 1958, the rise being especially steep from late winter to early spring. The lowest mean hourly value observed was about 20 micrograms/m³ and the highest near 100.

Superimposed upon these seasonal trends, and often of comparable amplitude, is a pronounced daily variation, with morning maxima (a secondary peak is common shortly after sunrise) and mid-afternoon minima (see fig. 1). This is attributed to the local circulation of up- and down-slope winds generated by the radiational heating and cooling of the mountain itself. As heated air rises in the middle of the day, the ozone is depleted by contact with vegetation, water droplets, or aerosols (suspensions in the air of fine solid or liquid particles) in the moist sub-inversion layer (below about 6,500 ft.).

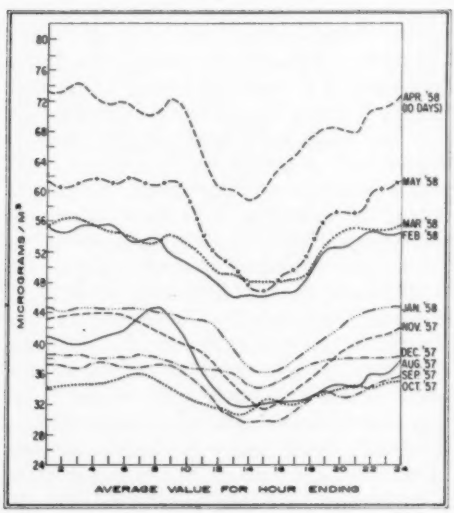


FIG. 1. Daily variation of surface ozone values at Mauna Loa Observatory.

Striking variations in the amount of surface ozone have also been observed to accompany changes in the broad circulation patterns of the Pacific area. Ozone increased abruptly with the transition from the prevailing trade-wind regime to a strong westerly flow around deep cyclones centered north of the Hawaiian Islands; it decreased again with the return of the trade winds.

Total Ozone at Mauna Loa: The Observatory's Dobson spectrophotometer was put into operation on 27 November 1957. This instrument determines depth of atmospheric ozone from the differential absorption by ozone of two spectral lines in the ultraviolet portion of the solar beam. The elevation of this particular instrument (the highest permanent installation of its kind in the world) and the clarity of the overlying atmosphere make its observations especially valuable for calibration purposes, principally in estimating solar radiation intensities outside the atmosphere.

Day-to-day variations in total ozone at Mauna Loa appear to be small; however, the actual amounts of ozone and the amplitude of the seasonal variation are high for that latitude. The amount varied from .250 cm in February 1958 to .288 in May. (Total ozone is measured in terms of the total thickness of ozone computed for an atmospheric column compressed to sea level pressure.) These values, as well as the observation of a seasonal peak later than that in middle and high latitudes, require further confirmation.

Surface Ozone at IGY Little America Station, Antarctica: Surface observations at Little America Station (78°S, 162°W) were made with the Regener chemical surface-ozone recorder. A marked feature of the annual variation (fig. 2) is the rapid rise of ozone values in April, when the sun disappears, and the slow decrease beginning in September, after the sun returns.

The dependency of surface ozone content on wind direction is shown in figure 3. Positive deviations from the average ozone concentration occur when the wind direction has a westerly component and negative devia-

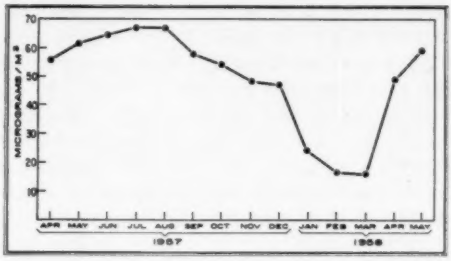


FIG. 2. Mean monthly surface ozone values at IGY Little America Station.

tions occur when it has an easterly component.

The daily variation of surface ozone concentration at Little America differs markedly from that in middle latitudes. Middle latitude stations usually report a maximum in late morning or early afternoon and a minimum in the late evening or early morning, believed to result from change in the vertical mixing caused by turbulence. In the afternoon, convective activity permits the ozone to be carried down from the upper air layers, but during the evening the lower layers become stratified and the downward transport weakens. Eventually, the surface ozone is destroyed more rapidly than it can be replaced from above and the concentration may drop almost to zero. At mountain stations, this daily variation may be wholly absent or it may be influenced by the daily variation of the mountain-valley wind.

At Little America during the Antarctic winter months the maximum occurs in the early morning, about 0300 local time (165th meridian); during the spring it shifts to 0600. The amplitude of the variation is rather uniform during the winter but is three times greater in September; it decreases again in the spring. (See table 1.)

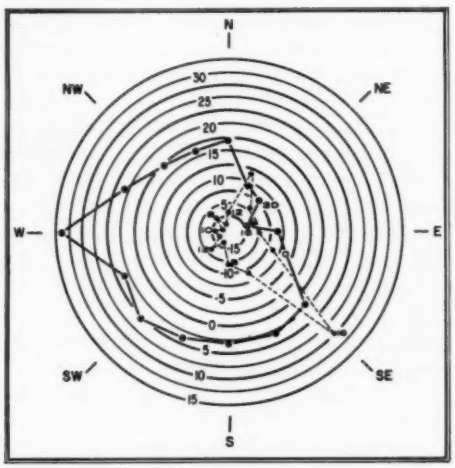


FIG. 3. Surface ozone and wind roses for IGY Little America Station, June 1957. Dashed line and lighter circles represent wind-direction frequency in percent of total time; solid line and heavier circles represent surface ozone in percent deviation from monthly average of 64 micrograms/m³ of air. Winds were calm 5.4% of the time, during which surface ozone deviated +9.5%.

TABLE 1

HARMONIC ANALYSIS OF DAILY VARIATIONS IN OZONE CONCENTRATION AT LITTLE AMERICA DURING 1957

Month	Amplitude* (micrograms/m³)	Time of maximum departure (hours after midnight)
April	2.7	2.0
May	0.6	2.1
June	2.2	2.6
July	2.0	2.9
August	1.9	2.7
September	6.1	2.9
October	2.6	4.0
November	1.2	5.5

* Average value of maximum daily departure from monthly mean value.

Total Ozone at Little America Station: Observations of total ozone at Little America (fig. 4) indicate that two maxima may occur —one during the winter and the other in late spring. The winter maximum must be confirmed by additional observations. The rise of total ozone toward the winter maximum begins one month later than that for surface ozone.

CARBON DIOXIDE

Air temperatures in the lower levels of the earth's atmosphere may be controlled to a large extent by the amount and distribution of CO_2 in the atmosphere, for CO_2 absorbs much of the energy radiated outward from the earth and radiates it back to the surface. The IGY CO_2 program has attempted to determine the present amount and distribution

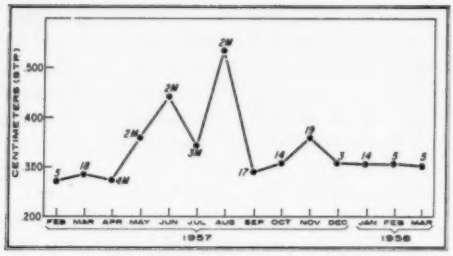


FIG. 4. Mean monthly total ozone values at IGY Little America Station under standard temperature and pressure conditions (STP). M refers to observations at full moon; all others made in direct sun. (Values are tentative, subject to further calibration of the spectrophotometer.)

of CO_2 in the atmosphere, as well as any evidence of long-run changes.

Scripps Institution of Oceanography Program: Scripps Institution of Oceanography, which had major responsibility for IGY CO_2 analysis, employed the following four methods of investigation:

1) Continuous analysis of CO_2 concentrations at points where local (industrial) influence is minimal—Little America Station, Mauna Loa Observatory, and Scripps' own location, La Jolla, California.

2) Analysis of flask samples taken at the 500-mb level (about 18,000 ft.) over the Pacific Ocean on U. S. Air Force Weather Service reconnaissance flights. Eighty-four samples were taken on seven flights.

3) Analysis of flask samples from a network of representative stations in the western hemisphere. More than 400 samples have been taken and analyzed.

4) Continuous CO_2 analysis during Pacific Ocean cruises. These include the Mukluk Expedition from San Diego, California, to the Bering Sea and back along the North American coast from the Aleutian Islands to San Diego, and the Downwind Expedition, from San Diego to Tahiti and to Valparaiso, Chile (see IGY *Bulletin No. 7*).

The program was made possible by the availability of a new, non-dispersive infrared gas analyzer with a precision of $\pm$ 0.2 part per million of CO_2 in normal air for most applications. Three of these instruments, at Mauna Loa, Little America, and La Jolla, are adapted for continuous air stream analysis. An additional instrument at the Scripps laboratory has been adapted for analyzing up to six flask samples an hour.

Over the Pacific Ocean, at Little America, at Mauna Loa, at Scripps Institution, and at several stations in the northern hemisphere where numerous flask samples have been collected, the CO_2 concentration appears to be nearly the same.

Continuous measurements at Little America show the smallest variations, about $\pm$ 0.3%. Mauna Loa shows a slightly larger variability, about $\pm$ 1.0%, and measurements during two ocean cruises show a variation of $\pm$ 2.0%. The small degree of variability for these areas is in striking contrast to current atmospheric CO_2 measurements in Scandinavia, where a range between 250 and 400 p.p.m., or a variation of about 60%, is reported (see figs. 5 and 6).

Woods Hole Oceanographic Institution Program: During August 1958, a series of 14 vertical soundings were made off the coast of Massachusetts with a CO_2 analyzer installed in the Institution's aircraft. The measurements were made east of Nantucket Island and, when weather permitted, over the Texas Tower on Nantucket Shoals. Routine meteorological observations were carried out in conjunction with the CO_2 measurements, which were taken at altitudes ranging from 100 to 10,000 ft.

The soundings indicated marked variations of CO_2 content with altitude, as previously noted in other areas. At Nantucket, an average difference of 10 p.p.m. was found from top to bottom of the profile, and larger variations were common. A CO_2 minimum was often noted between heights of 1,000 and 3,000 ft.

No correlation has as yet been found between CO_2 values and the various factors of air-mass identification, such as mixing ratio. However, the persistence of a given vertical CO_2 pattern over a period of three or four days was noted when meteorological conditions in the area were similarly persistent.

Texas Agricultural and Mechanical College Program: On the IGY cruise of the Texas A. & M. research vessel *Hidalgo,* continuous measurements of atmospheric and oceanic CO_2 pressures, particularly near the sea-air

interface, were taken. An interesting series of observations was made during a violent rain squall. A significant increase in atmospheric CO_2 was noted; at the same time, a very large increase (about 20–50 p.p.m.) of CO_2 in the water was measured to a depth of 200 ft., the maximum depth attainable with the sampling device. Twenty-four hours later the water column had not yet returned to its pre-squall level of CO_2 distribution; the atmospheric CO_2, however, returned almost to its original level in less than six hours.

In the Atlantic, the CO_2 pressure in the water was higher (about 1–25 p.p.m.) than in the atmosphere above the water on only two occasions. These were during and immediately following the rain squall, and in a series of measurements made in the Gulf Stream between Miami and the Bahama Banks.

In the Mississippi Delta region, a water area was observed where CO_2 pressure was greater than 1,000 p.p.m. In the atmosphere just above, a decrease in the CO_2 pressure was detected between air samples taken at 2 in. and at 25 ft. above the surface. These conditions, encountered when the ship was cruising downstream at 10 knots, persisted for about one hour. Both upstream and downstream from that area, conditions were more nearly normal for rivers: i.e., while the water had a higher CO_2 pressure than did the open Gulf or the Atlantic, it had a lower pressure than the air above it.

Nuclear Radiation

The Naval Research Laboratory conducted a program of daily air-filter collections at 20 stations along the 80°W meridian from Thule, Greenland, to Punta Arenas, Chile, in cooperation with the Weather Bureau and the meteorological services of several other nations. (See IGY *Bulletin No. 14* for back-

Fig. 5. Average index values of atmospheric CO_2—spring.

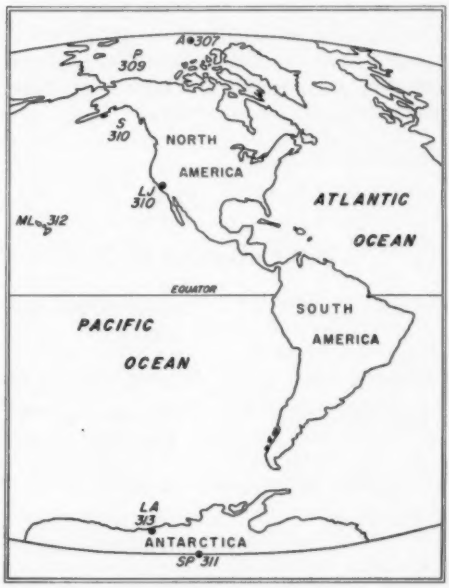


Fig. 6. Average index values of atmospheric CO_2—late summer and fall.

Note: The index values are based on a preliminary calibration; however, variability assessment depends upon comparative values rather than upon calibration. Stations as follows: LA—Little America; ML—Maura Loa Observatory; LJ—La Jolla; A—Drifting Station Alpha; CH—Cape Hatteras; L—Lark India flights; P—Ptarmigan flight; S—Stork flight; SP—South Pole.

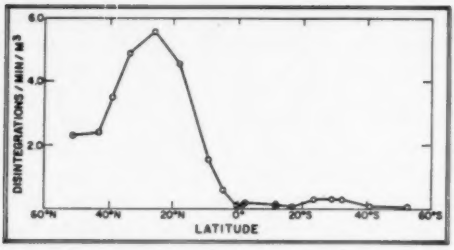


FIG. 7. Average fission-product concentration in the atmosphere during February 1958 along the 80°W meridian. Profiles for other months show a similar trend.

ground on other phases of the IGY nuclear radiation program.)

Very little fission-product radioactivity was found south of the equator (see fig. 7). Since most of the fission products were injected into the atmosphere in the northern hemisphere, the negative finding suggests that the exchange of air between the northern and southern hemispheres may be slow.

Apparently, radioactive decay, gravitational settling, and "scavenging" by precipitation removed most of the radioactive particles from the air before significant inter-hemispheric exchange could occur.

AIRCRAFT WEATHER RECONNAISSANCE IN TROPICAL AREAS

Weather data along two tropical flight paths were obtained by U. S. Air Force planes during several World Meteorological Intervals (IGY-designated 10-day periods including either a solstice or an equinox).

Twenty flights, two per day, were made between Puerto Rico and North Africa during the period 16–27 March 1958, partly at 6,000 ft. and partly at 20,000 ft. A total of 16 dropsondes (soundings of temperature, pressure, and humidity telemetered by instruments parachuted from the aircraft) were made along the route.

A more southerly "Special Tropical Track," from Puerto Rico to about 33°W, 13°N and return, also was followed. Four flights at 10,000 ft. were made on 18 and 26 September and 12 and 18 December 1957. On each flight, 13 dropsondes were made.

An important unknown of the tropical atmosphere has been the height of the trade-wind moist layer. Graphs of the horizontal variation of the moist layer, based on data obtained in the tropical weather reconnaissance program, are being studied in relation to perturbations in easterly trade winds, some of which develop into hurricanes.

AMS Calendar of National Meetings and Conferences

Washington, D. C.	General Meeting with American Geophysical Union	May 4–7
San Diego, Calif.	General Meeting with Pacific Division, AAAS	June 15–19
Denver, Colorado	Conference on Weather Modification with the American Society of Civil Engineers	August 28–29
Minneapolis, Minn.	Conference on Stratospheric Meteorology	Aug. 31–Sept. 2
Austin, Texas	With the Midwestern Conference on Fluid and Solid Mechanics	September 9–11
Chicago, Illinois	With the AAAS	December 26–31
Boston, Mass.	40th Anniversary Meeting and business meeting	January 19–22
New York, New York	With the Institute of Aeronautical Sciences	January 27
Santa Barbara, Calif.	Third Conference on Applied Meteorology	April
San Francisco, Calif.	Eighth Weather Radar Conference	April

Popular and Technical Books on Meteorology (1957-58)

MALCOLM RIGBY, Editor, *Meteorological Abstracts*

ABOUT seventy-five popular, scientific, or technical books on meteorology and the allied fields of earth science were reviewed by the author in the April, June, and October 1955, June 1956, and April and June 1957 issues of *Weatherwise*. These and as many more important popular, elementary, and advanced texts, a score of English language periodicals, along with many U. S. Weather Bureau publications for the post-war period (including a number for 1957 and 1958), were listed, with brief annotations, in two articles by Mrs. Evro Layton in the June and August 1958 issues of *Weatherwise*, under the title "A Selective Bibliography on Meteorology."

This review will attempt to bring the reader up-to-date on the recent English language books, both of a popular and of a specialized nature, without undue repetition of material in Mrs. Evro's excellent compilation mentioned above. Any additional books which come to our attention in the next few months will be reviewed in a later issue of *Weatherwise*, and the titles assembled and organized at some later date for ready reference.

RECENT REVISIONS OF STANDARD TEXTBOOKS

Descriptive Meteorology by Hurd C. Willett and Frederick Sanders. 2d ed. New York, Academic Press, 1959. 355 p. $7.50. This is intended as a comprehensive introductory course in meteorology for 3rd or 4th year college students. The composition of the atmosphere, stability, the heat balance, evaporation and condensation, wind, the general and secondary circulations of thermal and dynamic types, special winds, and finally weather modification and forecasting are the subjects of the major chapter headings. Considerable revision has been effected over and above the 1944 edition.

Sverre Petterssen, current president of the American Meteorological Society, published a two-volume revision of his classical 1940 textbook, *Weather Analysis and Forecasting*, in 1956 (see p. 99 of the June 1958 issue of *Weatherwise*). Now he has published an equally welcome revision of his famous 1941 elementary meteorology textbook:

Introduction to Meteorology by Sverre Petterssen, 2d ed. New York, McGraw-Hill, 1958. 327 p. Price $6.75. The original text was written for the wartime "rapid courses" in meteorology; the present revision is useful for beginners in professional courses in meteorology or allied fields such as geography, agriculture, aviation or engineering which require an understanding of the mechanisms which control weather and climate. Advanced physical meteorology and synoptic forecasting techniques have been deliberately avoided and little mathematics is employed. The atmosphere, instruments and observations, clouds and cloud or precipitation physics, heat and temperature changes, radiation and heat exchange; severe storms, haze, mist, smog and fog; laws of motion, local winds, general circulation and air masses; fronts, cyclones and anticyclones; tropical storms, world climate, and finally, weather lore and local forecasting—are treated for a general but fundamental understanding of each of these processes.

A companion book for the metorologist who wishes to keep his library up-to-date is:

Physical Climatology by Helmut E. Landsberg, 2d ed., revised and enlarged. Gray Printing Co., Inc., Dubois, Penna., 1958. 446 p. Price $6.00. The amount of factual material included in this informative and practical textbook on general and physical climatology (as distinguished from regional or geographic climatology) will bring great satisfaction to the user. The author includes in this revised edition a wealth of new material provided by the intensive applications of climatology during and after World War II; developments and applications in which the author played an eminent part in all theaters of the war and in all phases of application since the war. Thus the book brings to the

reader the latest knowledge and techniques in observing, analysis, and in applications to microclimatology, bioclimotology, topoclimatology, cryptoclimatology, climatic control, aids to forecasting, studies of climatic changes and trends, etc.

An excellent book in honor of the 250th anniversary of the birth of Benjamin Franklin, edited by a former president of the American Meteorological Society, is:

Atmospheric Explorations by Henry G. Houghton, ed. New York, John Wiley & Sons, 1958. 125 p. $6.50. This is a collection of five articles on various aspects of atmospheric electricity, each by an outstanding expert in the field: Cloud electrification by Ross Gunn; Vertical motions in atmosphere by Harry Wexler; Thunderstorm electricity by Jerome Kuettner; Ionospheric electrification by Henry G. Booker; and Lightning strokes by Loeb.

Another popular book has been revised to include the rapidly-developing aspects of global meteorology:

How about the Weather? by Robert Moore Fisher. Rev. ed. Foreword by Ernest Christie. New York, Harper, 1958. 172 p. The 1953 edition was entitled *How to Know and Predict the Weather,* and the first edition (1951) *How about the Weather?* This pocket-size book for high school students or adults who wish to make a hobby of observing and predicting the weather contains a large amount of literary material as well as recent scientific findings regarding the jet stream, hurricanes, long range forecasts, hailstorms, snowflakes, etc. Other chapters deal with temperature, clouds, pressure and circulation, air-masses, fronts, newspaper weather maps, fog, winds, storms, rules for local forecasting, weather and climate. A good subject index and excellent scenic cloud photographs add to the value and tone of the book.

Progress has been even faster in the field of space research than in the study of the atmosphere through which space travelers must pass; hence a book first published in 1957 required extensive revision and enlargement in 1958:

Space Research and Exploration by David Roberts Bates (ed.). New York, William Sloane, 1958. 287 p. $4.00. This contains a series of articles on rockets, space flight, cosmic ray and meteor hazards outside the atmosphere, earth satellites, manned satellites, space navigation, medical and biological problems, and conditions on the Moon and planets, written by British experts in the field such as L. R. Shepherd, M. W. Ovenden, H. S. W. Massey, D. R. Bates, Patrick Moore, A. C. Clarke and others.

Specialized Books

A thorough and scholarly book on a special natural phenomenon is always extremely satisfying to the lover of nature, no matter how elementary or advanced his background in that field. Such a fascinating book is: *The Green Flash and Other Low Sun Phenomena* by D. J. K. O'Connell, S.J., with photographs (80 in color) by C. Treusch, S.J., Vatican Observatory, 1958. Issued by North Holland Publishing Company of Amsterdam and Interscience Publishers, Inc. of New York. $6.00. Many scientists who observed this rare green rim on the upper limb of the sun just at sunrise or sunset during the past century convinced themselves that it was purely a physiological effect of the brilliant sunlight on the optical nerves of the eye. The color photographs made during the last decade at the Vatican Observatory, and reproduced so beautifully in this elegant volume, prove for all time that the phenomenon is real and not subjective, for the green or blue fringe or blob so often seen by mariners at sea or along coasts by observers, or in mountains when the air is clear and inversions are present, shows up vividly and unmistakably in dozens of these photographs. Others of the Moon and Venus also show the coloring just at the horizon, and in the case of Venus one can see the green flash on the upper limb and the red flash or fringe on the lower limb at one and the same time. The author presents the synoptic charts and adiabatic diagrams from nearby radiosonde ascents for each case where he has photos of the green flash. These analyses indicate that inversions are primarily responsible for the brief green or blue segment and that it is similar to a mirage. The book also takes up the history, theory, techniques and equipment of photography (both in color and black-and-white), and creation of artificial green flashes in the laboratory. A bibliography of 300 references to scientific or observational articles on the subject is appended. This is the perfect example of a con-

tribution by an astronomer who is conversant with meteorology.

Another must for the meteorologist's private library is:

Hurricane by Marjory Stoneman Douglass. New York and Toronto, Rinehart & Co., 1958. 393 p. Price $5.95. In this sizable book the author, who has written several best-sellers about the swamps and everglades of the Southeastern States, gives a readable but scholarly account of the hurricanes which have devastated our Atlantic or Gulf Coasts since the dawn of history, in a more or less chronological fashion right down to the year 1956. Nearly every important hurricane to hit the coasts or West Indies is chronicled in vivid literary language, with quotations from numerous sources such as Shakespeare (the Tempest), Oliver Wendell Holmes, and John Quincy Adams. The author did a tremendous amount of research in preparation for this book, spending several years consulting the U. S. Weather Bureau Hurricane Forecasters and the Hurricane Research Project personnel at West Palm Beach, Florida, in interviewing natives along the hurricane battered outer reefs of the Carolinas, Georgia, and Florida, and in studying legends of the Mexican Indians or Caribbean natives, accounts of shipwrecks or storm damage in hundreds of newpapers, and the technical and scientific literature from the days of Redfield and Reid to Cline and Tannehill, and the recent use of radar and airplanes in hurricane tracking or reconnaissance. An excellent bibliography and a detailed author, subject, and place name index is appended.

Dust by Irving Adler. Illus. by Ruth Adler. New York, John Day Co., 1958. 122 p. Price $3.75. Gives in simple language and by means of schematic drawings many interesting aspects of dust in the atmosphere, its cohesiveness, optical effects, effects on weather and climate, on soil and living organisms, allergies such as hay fever caused by dust or pollen, dust from space (meteoric dust), dust storms, visibility, mechanics, etc. It is hoped that many more such studies of particular meteorological elements or phenomena will be presented in readable book form.

Atlantic Hurricanes by Gordon E. Dunn and Banner I. Miller. Baton Rouge, La., Louisiana State University Press. First announced (p. 100 of June, 1958, *Weatherwise*) as "to be published late in 1958," it is now scheduled to be off the press in June 1959. We will be eagerly awaiting this timely contribution.

Supplementary Titles

Finally, we would like to call attention to a few titles which should not be overlooked, even though some of them have been cited by Mrs. Layton.

1001 Questions Answered about the Weather by Frank H. Forrester. New York, Dodd, Mead and Co., 1957. 419 p. $6.00. Dictionary-like answers to over 1200 questions about everyday weather, arranged in logical categories.

Physics in Meteorology by A. C. Best. New York, Pitman, 1957. 159 p. $3.75. A similar elementary book with a novel arrangement.

Atmospheric Electricity by J. A. Chalmers. New York, Pergamon, 1957. $10.00.

Physics of Clouds by B. J. Mason. Oxford, 1957. 481 p. $11.20. Good technical.

Cloud Study—A Pictorial Guide by F. H. Ludlam and R. S. Scorer. New York, Macmillan, 1957. 80 p. $2.95. Also: *Clouds* (filmstrip). London, Diana Wyllie, Ltd., 1958. Filmstrips DW-F19 and DW-F20, 24 and 25 slides, in color, with accompanying notes.

Weather Elements by Thomas A. and Robert C. Blair. 4th ed. Revised. New York, Prentice-Hall, 1957. 414 p. $6.75. Standard elementary textbook on Meteorology.

Climatology by W. G. Kendrew. 2d ed. New York, Oxford University Press, 1957. 416 p. $6.75. Standard textbook on climatology, brought up to date.

The Earth and Its Atmosphere by D. R. Bates, ed. New York, Pergamon, 1958. 324 p. $6.00.

The Weather Conditioned House by Groff Conklin. New York, Reinhold, 1958. 238 p. $14.75.

Weather Ways by Harvey Johnston. 2d ed. Toronto, Meteorological Branch, Dept. of Transport, 1957. 128 p. Elementary meteorology for pilots.

Wonder of Snow by Corydon Bell. New York, Hill and Wang, 1957. $5.00. illus.

He Tries to Do Something About It

LOUIS J. HENNESSEY, *Veterans Administration Center, Biloxi, Mississippi*

IT may seem rather strange that a Spanish-American War veteran, a man born way back in 1879, should in the late evening of his life take up such an abstruse science as meteorology for a hobby. But that is just what John M. Lott, widower and disabled old soldier, now receiving domiciliary care at the United States Veterans Administration Center, Biloxi, Mississippi, has done. And he has made quite a success as an amateur weather forecaster.

Coming to the Biloxi institution in 1953, and before he underwent two serious operations, Mr. Lott's health still permitted him to indulge in fishing, his favorite outdoor sport. He was in an ideal locality. Situated on a peninsula, almost completely surrounded by salt water, Biloxi holds much allure for disciples of rod and reel. Owning a small outboard motor boat, John Lott was in his element. The only fly in the ointment was the variable sub-tropical weather conditions. Sudden rains and squalls interrupted and spoiled more than one promising fishing expedition, Mr. Lott recalls.

"An impulse to take up weather forecasting," he said, "was due to a lack of readily available information pertaining to winds, rains, tides, etc., in this vicinity. And, having often heard that saying generally attributed to Mark Twain: 'Everybody talks about the weather, but nobody does anything about it,' I determined, in my humble way, to see what I could do."

When he took his momentous step, John Lott's acquaintance with anything having to do with a branch of science treating of the atmosphere and its phenomena was rudimentary, to say the least. He had never had any training of any sort along technical lines. His formal education consisted of two years in high school, followed by a course in bookkeeping at a business college. In early manhood, he filled a position as paymaster with the L. R. & N. Railroad, headquarters at Shreveport, Louisiana. He was born in north Louisiana of German-English parentage. Later on, he embarked in the general merchandise trade, made a success, and at the time of the stock market crash in 1929, was reckoned "fairly well off." The ensuing economic depression, coupled with poor health, compelled him to relinquish all commercial activities.

Regardless of ill-health, endowed with a keen, highly intelligent mentality, John Lott was not the sort to put up with a life of idleness. He came to Biloxi in a weakened, run-down state, but at no time did his mind fail to function clearly. It was in 1954, the year following his arrival at the V. A. Center, that he determined to embark upon a study of meteorology.

He could hardly have selected a more promising or more difficult locale for his operations. The Mississippi Gulf Coast is noted for its changing weather conditions, and Biloxi is one of its most unpredictable spots. Facing Mississippi Sound, a shallow body of water extending 70 miles in a westerly direction from Mobile Bay to the Louisiana line, a chain of sand islands partly separating it from the Gulf of Mexico, Biloxi offers a challenge to the most astute weather prognosticators. Warm in summer, fairly cool in winter, enjoying an annual rainfall close to 60 inches, it is one of the wettest spots in North America. Essentially a resort, entertaining thousands of visitors winter and summer, its prosperity is bolstered by a highly lucrative seafood canning industry, plus two large Federal government installations. One of these is Keesler Field, the big Air Base, whose combined civilian and military personnel totals 17,000.

Adjacent to Keesler Field is the U. S. Veterans Administration Center, on the extreme left, or north side of the Biloxi peninsula. Facing Back Bay, which is a continuation of the Bay of Biloxi, itself an offshoot of Mississipi Sound, the V. A. Center is generally regarded as one of the finest institutions of its kind in the United States. It embraces 369 beautifully landscaped acres and has a

frontage of 6,000 feet on Back Bay. With a length of eight miles, averaging from a half to three-quarters of a mile wide, the Bay has a marked channel with a minimum depth of eight feet. Several small rivers and bayous empty into it, affording sheltered harbors for fishing craft and pleasure boats in time of hurricane.

The Back Bay Amateur Weather Station, under the sole direction of John M. Lott, is located on the third floor of a domiciliary, or barracks, directly facing Back Bay. His bedroom is just inside a screened gallery where most of his instruments are kept. This, in view of his none too robust physical condition, makes for a most convenient arrangement. Up and out every morning before sunrise, he consults his instruments, makes observations, reads carefully his U. S. Weather Bureau map, and prepares to draw up his daily report. Four years ago, his total equipment consisted of a wind speed indicator, barometer, and a thermometer, making a total expenditure of $60.00. But today his observatory has the following:

> National Radio, standard band with three short wave bands up to 40 M.C.; government surplus radio, band 11–550, K.C.; Zenith radio, battery model, portable; pair of field glasses, 10 power; telescope, 30 power; globe, 18 inches; Thermograph; Hygrothermograph; maximum-minimum thermometer; sling psychrometer; rain gage; wind speed indicator; deluxe Barograph; Rexograph, model S.A.; Smith-Corona typewriter.

The above represents a cash outlay of $1,250.00, and came out of a modest monthly pension granted John Lott by the Federal government for service in the Spanish-American War. In their selection, along with instructive reading matter, he feels greatly indebted to the editors of *Weatherwise*. Mr. Lott now is saving up to buy a short wave, four wave bands radio, so as to be able to get on the U. S. Weather Bureau frequency. Nearby sources of radio intelligence at present are the offices at Miami and New Orleans. These two are important especially in the months of June, July, August, and September, when hurricanes are apt to come roaring out of the West Indies. Biloxi is fortunate in not having had a major tropical storm since the king-size blow of 1947.

In the winter months, Mr. Lott scrutinizes most carefully temperatures and wind currents in the North and Northwestern States. Using the path system, he is able to make a pretty dependable estimate of weather to be expected along the Gulf Coast. There being no weather stations to the south, he is greatly handicapped by lack of data bearing on what is going on in the watery wastes of the Gulf of Mexico and the Caribbean Sea. This can upset all calculations pointing to a bright, sunshiny day. A cold front sweeping in from the north or northwest, may unexpectedly encounter a mass of warm air drifting in from the Gulf. The resultant condensation and precipitation due to a clash of the elements, may give Biloxi a torrential drenching of six or more inches.

Despite the hazards of weather forecasting along the Mississippi Gulf Coast, John Lott has established an enviable reputation for accuracy at the Biloxi V. A. Center. His prognostications are eagerly awaited by doctors, nurses, technicians, fishermen, engineers, maintenance men, and others included in the 1600 members of both sexes working or living on the reservation.

"We are well aware of and deeply appreciate a most useful function being performed by John M. Lott," declared Major E. A. Hiller, manager of the Biloxi institution. "His daily weather reports are of especial value to our engineering department. What he is doing should serve as an inspiration for others, proving as it does that neither age nor ill-health is an insurmountable barrier when a man of determination sets out to accomplish something worth while."

Obituary

The sad news has just been received that John Lott passed away recently. We hope that this will serve as a fitting memorial for John Lott and that it may serve as an inspiration for our readers of all ages.

Data by Office of Climatology, USWB.

An Active January and a Varied February 1959

DAVID M. LUDLUM, *Editor*

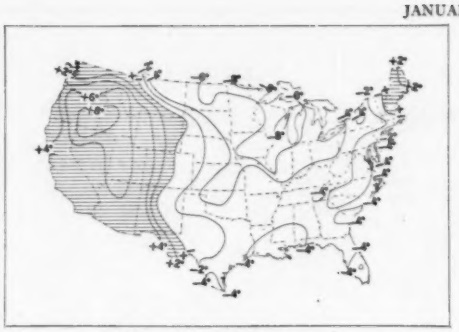
CIRCULATION—A comparison of the mean circulation maps for December and January reveals a general similarity in the location of troughs and ridges and in the distribution of pressure contours. Indeed, there was a very definite persistence in the average temperature and precipitation regimes from the first winter month to the second. Yet, imbedded in the January weather picture were a grand variety storms and events which reflected frequent changes in the day-to-day circulation pattern. For most of the country there was little resemblance in the air flow between the first two weeks and the final two weeks, so the month can best be analyzed as two distinct periods.

As the month opened, a complicated frontal system, associated with a marked upper-air low over Saskatchewan-Manitoba, spread across the Canadian Prairies and the northern American Rockies, while far to the north in the Yukon an anticyclone of great magnitude (1056 mb—31.18″) was poised. Soon a strong northerly stream aloft raced southward over the Plateau and Rocky Mountain areas, heralding a vigorous outbreak of Arctic air. At the surface the low dome of frigid air forced a passage through the passes and over low mountain barriers to coastal Washington and Oregon on the 3rd, bringing an intense, though brief, visitation of winter there. The cold air swept southward into California on the 4th carrying freezing to the central California coast (Santa Maria 30°). Snow accompanied the frigid blasts at low elevations in western Oregon and Washington, the first there since 1957.

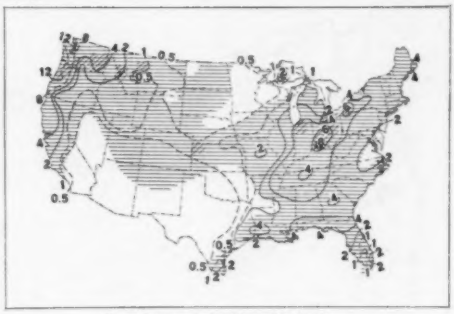
A companion stream of cold air rushed down the eastern flank of the Rocky Mountains and penetrated far southward to drop temperatures abruptly over the central and southern Plains. The reading of −26.2° at Goodland in western Kansas on the morning of the 4th was the lowest ever registered since the establishment of the station in 1895; and the −11° at Amarillo in the Texas panhandle exceeded the all-time January low there. Freezing reached to the southernmost tip of Texas, at Brownsville, a sea level location at 26° N, where the mercury touched 31° and a trace of snow fell for the first time in 10 years.

The initial phase of January's weather ended on the 4th when the temperature rebounded from the extremes of that morning, and by the 5th a general warming trend was evident over most of the nation west of the Mississippi. The air circulation in the West shifted from a northerly component to an almost straight west-to-east flow and remained so for the next week.

In the East the cold air streams flowing out of



Departure of Average Temperature from normal in degrees Fahrenheit. USWB chart.



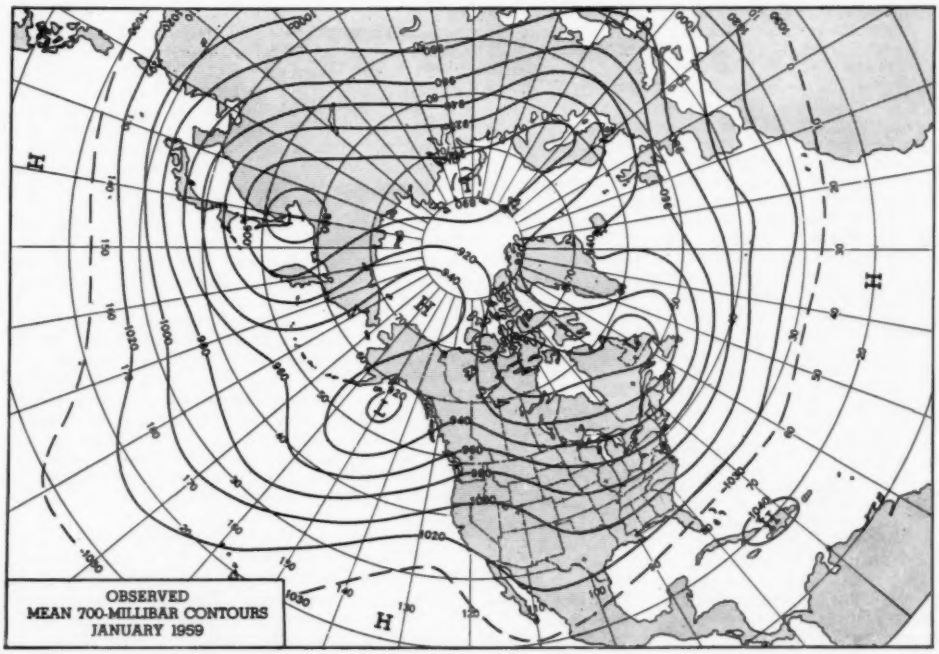
Total Precipitation in inches. USWB chart.

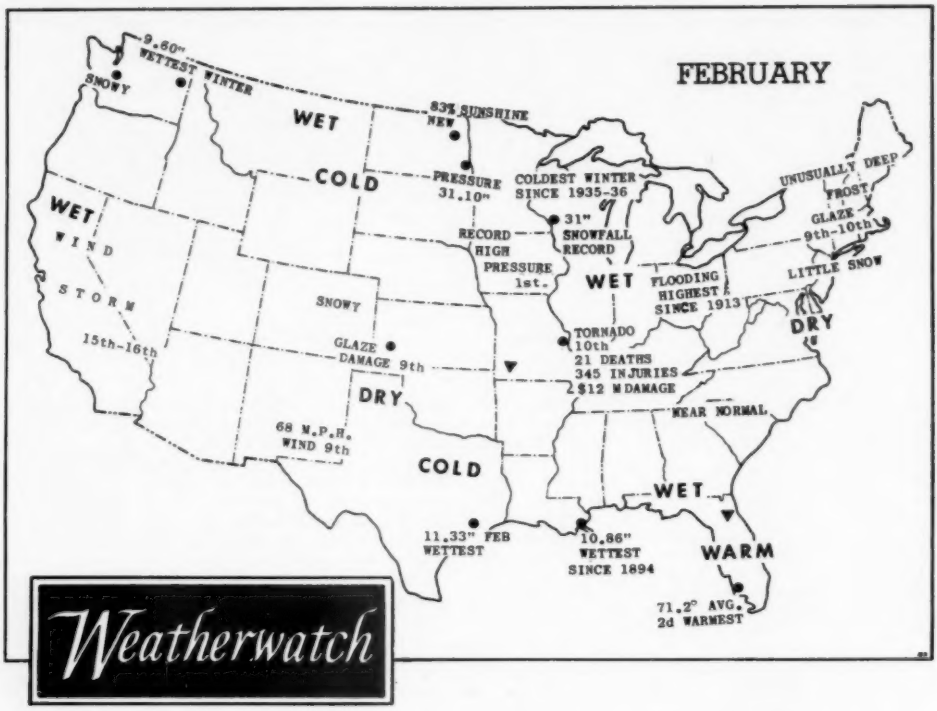
the Northwest penetrated to the Atlantic Coast late on the 4th and set up an interesting wind pattern. A deep vortex extending from the surface to great heights developed over southeastern Canada in the general vicinity of the Gulf of St. Lawrence where it remained for six full days until the 11th. The stalled low reflected the dominating influence of a blocking anticyclone over Greenland-Iceland region, a more or less permanent feature of recent monthly mean maps. Upstream from the stalled vortex, a stationary ridge remained over the Hudson Bay area with an extension south-southeastward into the United States—this provided a channel for a steady northwest flow of frigid air, accompanied by gusty winds of gale force, over the Northeastern States for seven consecutive days.

On the western side of the central ridge, the warming trend already noted continued as mild Pacific air flowed in from the relatively warm ocean and poured eastward over the Rockies and down onto the western Plains. On the 11th and 12th many stations over a wide area set date records for maximum temperatures, just as they had a week previous for low marks.

(*Continued on page 82*)

The upper-air map below shows the pattern of air flow for January at about 10,000 feet, on which the average weather largely depends. The contours lines represent the mean height of the 700 mb. pressure level. Figures are in tens of feet: 1020 = 10,200 ft., 980 = 9,800 ft., etc. Chart by Extended Forecast Section, USWB.





FEBRUARY CIRCULATION—After producing many exciting weather events in December and January the weather elements entered on a rather peaceful period in February. Most noteworthy in the monthly summaries from stations across the United States was the lack of reports of severe storms. With the exception of the St. Louis tornado storm system, there were practically no outstanding weather news headlines. From the strictly meteorological point of view the most interesting event occurred during the first hours of the month when barometers in the upper Mississippi Valley topped 31.00 inches to set many stations records for all-time maximum pressure.

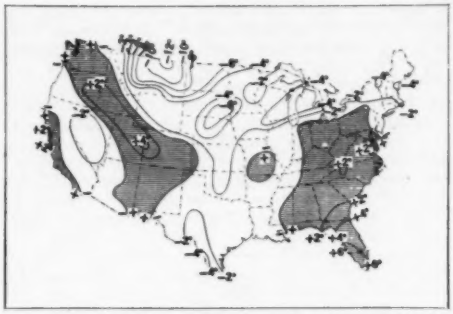
The shift in upper-air circulation across the country first noticed about 24 January continued to hold sway through the entire month of February. Above normal westerly flow characterized all periods throughout the month. Strong westerlies usually mean containment of Arctic air in northern regions, and this is what occurred. Only the northern border states from Montana eastward to Maine were unusually cold as a result of air, circulating around a deep, persistent vortex in northeastern Canada, sweeping surges of coldness southward, then hurrying it quickly eastward. The cold air did not penetrate for any continued periods farther south than Nebraska and Iowa or the Ohio Valley.

To the west of the crest of the Rockies a broad band of above normal temperatures, spreading from Washington to New Mexico, appeared on the February chart, showing the effects of Pacific air masses swept in by the strong westerlies. East of the Mississippi River and south of the Great Lakes, the scene was dominated by Gulf air masses and a rather mild month followed there. Thus, the country was divided into three parcels, each having its own prevailing air mass: Arctic in the north, Pacific in the West, and Gulf in the East and Southeast.

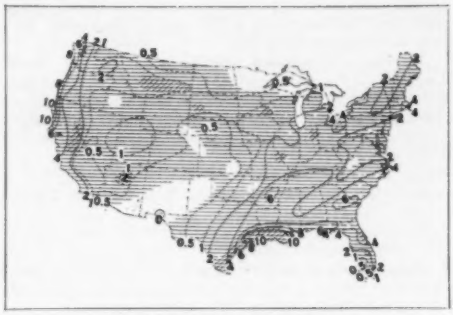
To be sure, there were some breaks in the hold of the respective air masses on their territories. Westerly flow in from the Pacific was interrupted three times as cold lows formed over the Plateau and moved eastward on the 3–5th, 9–14th, and 20–23d.

The first low development brought a surge of cold air down from Canada over the Rockies and Plateau all the way to the Mexican border, dropping temperatures below normal in Arizona for the first extended period in a month. The second cyclonic development was associated with two cold lows over the Plateau—one of these developed the complicated frontal system and juxtaposition of air masses which spawned the St. Louis tornado (see p. 43). The final storm period extended from the 20th to the 24th as two distinct lows from different quarters converged on New England to create a rugged winter week. The first low exhibited an unusual movement, coming southeastward from northern Canada, across Hudson Bay, and into New England on the 20–21st; and to show how alert forecasters must be, the second came directly eastward at tremendous speed from Nevada to the Maine coast on the 22–24th.

Precipitation for the month countrywide was generally heavy, though not excessive in any one area. The Pacific Coast was wet as west westerly winds brought moisture ashore. The Gulf States, excluding Florida peninsula, were also wet. To the north the cyclone track from Nebraska to New York con-



Departure of Average Temperature from normal in degrees Fahrenheit. USWB chart.

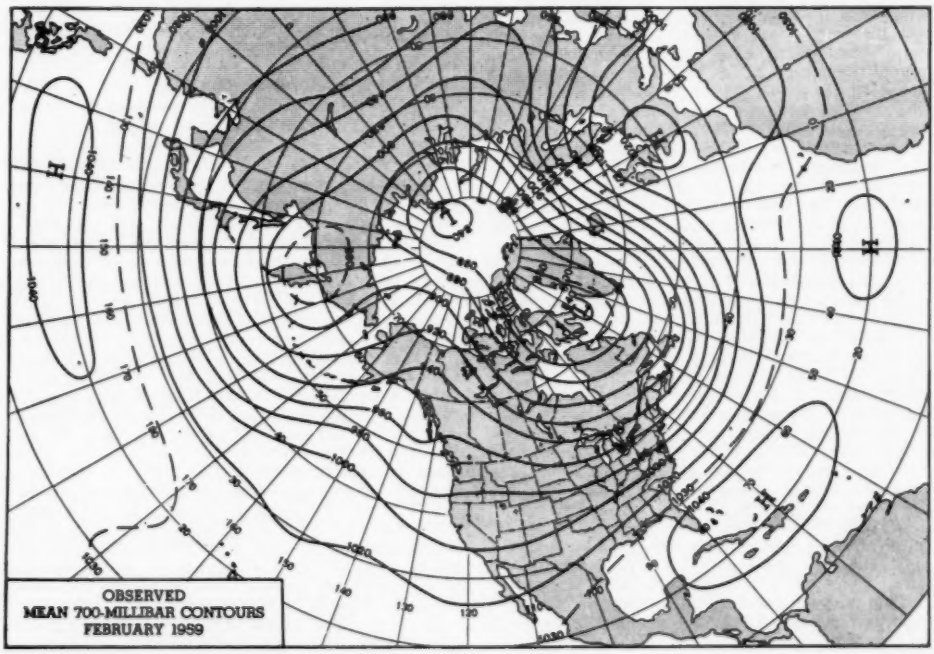


Total Precipitation in inches. USWB chart.

tributed much snow and sleet to the already adequate snowcover.

NEW ENGLAND HOLIDAY—"Up to 7 inches of snow on 23d and 24th snarled holiday traffic and caused many skidding accidents. Total snow depths in central and northern New England now range from 15 to 40 inches. Moderate precipitation on 18th in north and east, continuing into 19th in northern Maine, with totals decreasing southwestward to traces over southwestern Massachusetts and western Connecticut. Precipitation was in form of rain in southeast, rain changing to snow over central, and as 4 to 8 inches of snow in north. Persistent cold after 18th with average for week 3° below normal in Connecticut and Rhode Island, and 4° to 9° below elsewhere. Lowest reported was −31° on 24th at Presque Isle, Me. Many northern communities experienced rash of frozen water pipes, as frost reached unusual depths in ground. Greater snow depths this week relieving this situation. High winds with gusts of 40 to 50 mph; from 19th to 21st intensified effect of cold but caused only minor damage. Cold, stormy weather tended to limit farmwork to chores and other inside jobs, but considerable effort expended in shoveling and plowing snow." New England Climatologist in *Weekly Weather and Crop Bulletin*.

A GREAT ANTICYCLONE—During the opening minutes of February a high pressure area of great magnitude crossed into North Dakota and Minnesota, and barometers were soon indicating all-time high readings. At Minneapolis-St. Paul, where good barometric records have been maintained since 1870,



the pressure reached 31.07″ (1052.3 mb) near mid-morning to exceed the former record of 31.00″ which had been touched twice before on 28 December 1917 and 26 January 1927.

The highest pressure was noted at Fargo, North Dakota, on the Minnesota border where the barometer attained 31.10 or 1053 mb. This was the highest reached at Fargo since 1917 when the all-time mark of 31.18″ was set. Old timers will recall that the 1917 occurrence accompanied a famous Arctic outbreak which established records for all-time low December temperature readings from the Rocky Mountains to the Atlantic Coast.

Pressure above 31.00″ were generally reported on the morning of 1 February 1959 from most of North Dakota, much of eastern South Dakota, all of Minnesota, most of Iowa, western Wisconsin, and parts of northwestern Illinois. The high pressure area was somewhat unusual in that it possessed no unusual strength during its stay in Canada from 25 to 31 January. Pressures did not approach 31.00″ until it reached the U. S. border. And its period of great strength lasted less than 24 hours. By midnight of the 1st nowhere were barometers above 31.00″. A frontal system cut the anticyclone from its Arctic source so that central pressure rapidly diminished as it moved eastward over the Ohio Valley to the Atlantic Coast where it stood at midnight of the 2nd at 30.57″—1035.5 mb.

January (*Continued from page 79*)

A change in general circulation patterns commenced on the 14th as a deep trough developed over the Great Plains, and with some ebb and flow would remain near the Mississippi Valley for the remainder of the month. This provided a new situation as ridges built up both to the east and to the west to lock the trough into a steady position. The first storm development came as a weak circulation, over the northern Plains early on the 14th, soon moved to the Lakes region where rapid deepening took place as warm Gulf air entered the circulation. The frontal system and pressure center traveled eastward to the New England coast at a rather slow pace, permitting the production of much rain and snow over northern regions. Turning directly northward over New England, the low center traversed Quebec in a northwestern loop and joined a developing vortex over Hudson Bay at the northerly end of the Mississippi Valley trough which now became the principal pressure feature of the continent.

The shift of the position of the Canadian vortex from a southeastern location to the Hudson Bay region spelled an intensification of the cold regime over the upper Middle West and a moderation in New England and the Middle Atlantic States. With a trough extending southward from Hudson Bay to the southern Plains, the main axis of Arctic flow southward entered the country west of Lake Superior. International Falls, Minnesota, experienced below zero readings every night from the 14th to the end of the month. In many north-central locations it was the coldest January since 1929, and in central Michigan it was the snowiest as well.

The central trough feature soon gave birth to the major storm of the month when cyclogenesis took place on the 20th along an existing southwest-northeast frontal zone, extending from Texas to New Jersey, which had already enabled precipitation to break out over a wide area just north of the front. Rapid development of the center took place on the 21st as it passed northeastward from Arkansas to Lake Erie with pressures dropping to 29.00″ as it entered Canada and later reaching 28.35″—960 mb upon joining the Hudson Bay vortex. See pages 45–48.

After three weeks during which varying streams of air fought for control of the American weather scene, the elements seemed eager to enter a period of relative tranquility. A general increase in westerly flow was noted after the 22nd when a high index of westerly circulation in middle latitudes set in, and Pacific air flowed inland to reach most central and southern sections of the country. The Hudson Bay low center still remained vigorous to maintain an Arctic flow over northern border sections, but cold air was unable to penetrate farther southward. Temperatures along the Canadian border remained near the zero mark, but other sections found relief. In the East the last week of January saw the development of two thermal zones: north of Virginia it remained cold as continental air swept around the Hudson Bay low; but the Southeastern States experienced a welcome relaxation from the winter regime which had held steady since the early days of the month and aroused fears that the disasters of the winter 1957–58 might be repeated. The Florida peninsula now basked in much above readings, a situation which would continue for the next thirty days and allow a restoration of the area's solar reputation.

WINDY NORTHEAST—Wind comprised the principal feature of January weather over the Northeastern States. Anemometers whirled steadily, while wind vanes shifted back and forth, as fronts passed in quick succession throughout the month. The most memorable blow occurred from late on the 3rd through the 7th when a low pressure system stalled over the Gulf of St. Lawrence area and kept the northwest wind machinery in constant operation. Atop Mt. Washington (6,002 ft.) in New Hampshire the fastest mile of wind measured exceeded 100 mph on four consecutive days, and on the first three days the average wind movement topped 75 mph. Consider the comforts of the weathermen atop the mountain on the 6th when the average wind speed clocked 92 mph and the mean temperature stood at $-24°$.

At low levels gale winds from 40 to 50 mph prevailed with gusts reaching as high as 75 mph, to put a real sting in the cold. Temperatures on the 5th and 6th in the northern states did not rise above $+10°$—the combination of wind and cold gave as unpleasant a period as New England has known in many winters, and reminded some of the historic "Cold Friday" on 19 January 1810 when a bitter gale swept the New England countryside carrying tragedy and hardship.

Central pressure in the stalled low over the Maritime Provinces remained close to 28.25″—957 mb for two full days. To the west a finger of high pressure of 30.60″—1036 mb stood firm and pumped bitter cold air into the area. Along the lee shore of Lake Erie and Ontario continued snowbursts added to the already record snow cover.

Another windy day accompanied the quick January thaw which was associated with the great Midwestern storm of 21–22 January. At Boston the mercury soared to 62° early on the 22nd accompanied by a 40 mph wind out of the southwest. Wind gusts were generally well above 30 mph during the approach of the cold front even at points well inland. The wind-driven warm rain greatly accelerated the snow melt and subsequent flooding.

Humiture (*Continued from page 56*)

muting back and forth to my office on Wall Street for the past thirty-five years, the last five from Essex Fells. My other vocation, besides weather, is public relations. I love words; words are like music to me, and a good many years ago I began to examine critically some of the words we apply to the weather.

It struck me, almost a quarter century ago, that our standard weather vocabulary was inadequate in one very important respect. At that time, when we had a sweltering summer, or a damp winter day, the newspaper stories and the announcements on the radio did not stress the effect of the humidity. All the public was informed about was the temperature, and it seemed to me that this was only half the story.

I inquired, and found that the Weather Bureau people were of course well aware of the significance of air moisture as a factor in the human reaction to weather. From them I learned of "absolute," "relative" and all the other kinds of humidity, and I was initiated into the psychrometric mysteries of dry bulbs and wet bulbs. I read up on the subject, and arrived at some conclusions of my own.

There seemed to me to exist a real need for a word that would express the combined effect of air temperature and atmospheric moisture. It also appeared that the relative humidity was the natural indicator of the moisture term in the combination I envisaged. I appreciated the scientific limitations of relative humidity, and I realized that the dew point, or the depression of the wet bulb, was technically preferable. As a public relations man, however, I was convinced that it was more expedient to begin with a term that the public might at least recognize and build upon, rather than to start and finish with a word or method that were obscure. Moreover, after experimenting with various combinations, it seemed to me that the semantic union I proposed between air temperature and relative humidity, giving the "root" to the latter, had more logic to it than might superficially appear. In other words, I did not preside over the nuptials with a shotgun.

So there I was—with a concept that needed to be christened (if I may shift my metaphors). The word "humiture" came out of nowhere (to quote "The New Yorker") in September 1937. From it the unit of measurement "humit" developed, nine years later. And so I began stressing humiture as the average of the air temperature and concurrent relative humidity, and started expressing the result in terms of humits. "It isn't the heat, it's the humiture" was my switch on the time-worn jest, and I began keeping a daily record of the number of humits that New Yorkers experience. Sixty to seventy humits is the normal comfort range. I observed that when they went over 70, folks were generally uncomfortable, at 80 miserable.

I have been lucky. I have lived to see my inventions defined in all the principal dictionaries, printed in the newspapers and broadcast over TV and radio stations. My comfort norm is heard or read not only in New York City, but also in Boston, Richmond, and Chicago and even in Paris, France.

"I should think you'd jump out of your skin!" was the way my wife put it one evening recently when humiture announcements were given over four different radio and television stations. The truth is, while I am delighted at the favorable reception my brain children have been accorded, I am deeply humble and somewhat awed. I have put in a lot of work on humiture. At times I was belittled. What sustained me was the hope of making a contribution to my fellow man, and to the science of which I am an amateur practitioner.

I believe that, as matters now stand, the relative humidity is likely to be replaced by the wet bulb temperature, insofar as the "man on the street" is concerned. I believe that the public has become sufficiently weather-conscious over the past twenty-five years to be able to understand and apply the term. I think that the younger generation, thanks to better courses in meteorology in the grade and high schools, is even more weatherwise. I argue: Why say two things (air temperature and relative humidity) when one word will do?

Some meteorologists have criticized humiture as scientifically unsound. I respectfully dissent. It is not the best technical expression of the temperature-humidity relationship, granted. But it is at least as good as what it was designed to replace (dry bulb and R.H.

separately) and it is at least twice as simple to apply. Furthermore, what I feel I attained, was something that would be acceptable to the general public without being altogether anathema to the scientists.

In spite of the above, and to return to my point, I do feel that eventually my present formula for humiture will have to be revised. In the distant future after the public has absorbed the first, or transitional, definition, I believe that it will be ready to use a humiture index in which the moisture component will be the direct wet bulb temperature. In other words, some day humiture will be the average of a pair of simultaneous dry and wet bulb readings. In my humble opinion, this is the ultimate comfort norm. It makes much more sense, scientifically, while retaining all the convenience and simplicity of the present, temporary definition. But, first things first. The step from separate announcements of the dry bulb and the R.H. to their joint packaging under the label of humiture has required twenty years to take effect. It will be about that long, again, I think, before the next advance will be made. Then we will have a handy expression which, in my judgment as a public relations man, I am confident the public will buy. Since this expression will be my ultimate form of humiture, redefined, I am equally confident that it will be scientifically acceptable as well.

Though I do not wish to pose as a weather expert—I am an amateur, like most of you readers—perhaps I can dwell for a moment on this last point. In 1946, when I developed the humit as the unit for expressing humiture, I experimented with this simple equation:

$$\text{Humiture} = \frac{\text{D.B. Temp.} + \text{W.B. Temp.}}{2}$$

For the reasons of expediency outlined above, I did not attempt to publicize the definition, but concentrated on the preliminary form, in which the R.H. is substituted for the W.B. I did continue to play around with the W.B. form of my humiture equation, however, keeping track of it in my charts of indoor and outdoor comfort conditions.

Recently, I came across an article by Earl C. Thom, a research climatologist in the headquarters of the Weather Bureau in Washington, D. C. I was delighted to read in this article (and I am happy to list it in my bibliography) that Mr. Thom had developed, apparently between 1952 and 1956, a concept that has, in some respects, a similarity to my own.

This concept is ably explained by Mr. Thom in his article (1) but I want to prove my point so I will very briefly describe it here.

Mr. Thom started from the Effective Temperature, a measure of meteorological comfort developed by the American Society of Heating and Air Conditioning Engineers and accepted as authoritative by this group and other interested parties. He found that the Effective Temperature, which requires formidable equations and graphs to derive, could be closely approximated by the simple aver-

MAY 1958
12 NOON—NEW YORK CITY

May	Dry bulb	Wet bulb	Relative humidity	Humiture*	
				(R.H.)	(W.B.)
1	55.1	49.8	69	62	52
2	66.7	54.7	45	56	60
3	48.2	47.6	95	72	48
4	50.0	49.5	96	73	50
5	49.5	48.3	91	70	49
6	46.2	44.8	89	68	45
7	45.0	44.5	97	71	45
8	49.3	47.7	88	69	48
9	63.0	55.0	60	62	59
10	57.1	45.8	39	48	51
11	61.4	58.7	85	73	60
12	66.7	52.7	37	52	59
13	62.1	49.0	36	49	56
14	62.0	46.9	28	45	54
15	49.2	47.0	85	67	48
16	55.3	53.0	86	71	54
17	63.0	56.2	65	64	60
18	63.4	60.5	85	74	62
19	76.2	67.8	65	71	72
20	56.7	55.8	95	76	56
21	66.3	48.9	24	45	57
22	63.2	50.5	39	51	57
23	61.9	52.0	50	56	57
24	61.0	52.5	56	59	57
25	60.8	59.7	94	77	60
26	59.1	50.1	51	55	55
27	67.8	55.7	45	56	61
28	71.8	62.1	58	65	67
29	61.9	50.6	44	53	56
30	70.1	55.7	38	54	63
31	73.4	58.2	39	56	66

* Humiture (R.H.) = dry bulb + relative humidity ÷ 2.
Humiture (W.B.) = dry bulb + wet bulb ÷ 2.

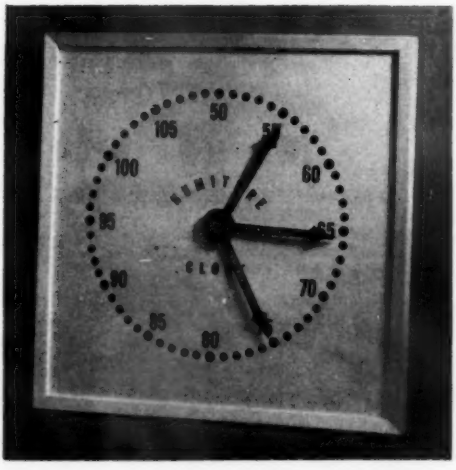
age of a pair of simultaneous dry bulb and wet bulb temperatures multipled by 0.4 with 15 added. Mr. Thom named it the "Discomfort Index." Tests have convinced me that the increase in accuracy is slight and that for practical purposes the simple formula (one-half D.B. plus one-half W.B.) is valid.

I mention the above not to take anything away from Mr. Thom's excellent work, but merely to show that, earlier and under another title, my idea has been demonstrated to have a firm scientific foundation and potential value to the rapidly growing field of air conditioning.

Speaking personally, and with a bow in Mr. Thom's direction, I prefer "Humiture" to "Discomfort Index" as the name for what I hope will one day be a very familiar weather term. Through increasing daily use in the press and on the air, millions in the Metropolitan Area of New York are well acquainted with it. Patents which I have just been granted for the mechanical and electronic control of the "Weather Clock" giving direct readings of humiture, as well as of its two components, will, I hope, result in the availability of an instrument which also will become quite familiar to the general public.

REFERENCE

1. Thom, Earl C., "A New Concept for Cooling Degree-Days." *Air Conditioning, Heating and Ventilating*, June 1957.



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(*Continued from cover 2*)

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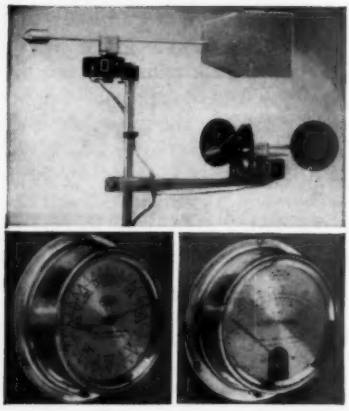
Material prepared by Prof. Spar about the program is being directed to officers of the fifty-three local seminars of the American Meteorological Society. These local representatives may contact secondary and private schools in their areas. Prof. Spar is also Chairman of the Schools Committee of the Society that is concerned with secondary and elementary education.

The American Meteorological Society is also carrying on a Visiting Lecturer Program in the colleges and universities under sponsorship of the National Science Foundation that has been announced previously.



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